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The Calendar

The calendar is a man-made device for the purpose of recording the repetitious phenomena of the heavenly bodies. Each time the earth completes a rotation on its axis, the calendar records a day; each time the moon completes a revolution around the earth, the calendar, approximately, records a month; each time the sun completes its cycle of movement among the stars, the calendar records a year; each time the celestial pole completes a circle in the sky, the calendar records a Great Year. (Since this last is some 26,000 ordinary years in length, it will not concern us greatly at present.)

The day, the month, and the year, as determined by natural events, are not commensurable with each other, consequently adjustments are necessary from time to time to keep the calendar in step with the actual circumstances. These required adjustments are thoroughly understood and the present calendar will serve its purpose for an indefinite period. In fact, it has become so set that any modification of it would be accomplished only with the greatest difficulty. This is so because, although the astronomer's knowledge is essential to its construction, every civilized person makes use of it and instinctively resists change.

However, any thoughful person upon reflection will agree that at one point a change is desirable. The distribution of the days in the several months is arbitrary. As at present it is irregular, inconvenient, and irrational. Historically it represent the whims of several ruling monarchs and not a scientific necessity. An arrangement whereby one might know, without looking at a printed schedule, the day of the week on which a given date would invariably fall, would be a vast improvement. Such an arrangement has been devised and is strongly advocated by some.

Now we are aware that we are living in One World and that civilization is undergoing fundamental and radical changes. It would seem, therefore, that the time for a highly desirable and greatly needed Calendar Reform is here.

Motions in the Solar System*

By H. R. MORGAN

A paper in POPULAR ASTRONOMY, December, 1943, dealt with the positions and motions of the stars. The following has to do with things in the solar system, and more especially with the observational work, the tables of the sun, moon, and planets, and the astronomical constants.

Introductory. The reader will recall that the gravitational system as known today was explained less than three hundred years ago, when, with the aid of the heliocentric theory of Copernicus, the observations of Tycho and Galileo, and the laws of planetary motions derived by Kepler, Newton discovered and established the law of universal gravitation, and explained all the important motions in the solar system by it. Newton, and a long list of mathematicians following him, among whom Euler, Clairaut, D'Alembert, Lagrange, and Laplace were outstanding in the early work, developed the complicated theories of the planetary and lunar motions with most complete mathematical analyses, and gave to the world Celestial Mechanics. It takes four large volumes of Tisserand's *Mécanique Céleste* just to outline the more important analyses in the subject up to about fifty years ago. Among the subjects the student may think of are: the development of the calculus; the law of central forces and elliptic motion; the differential equations of motion for the problems of two, three, and n bodies; the expansion of the perturbative function in infinite series with different independent variables; the various methods of integration of the equations of motion; the canonical equations; Bessel functions; variation of arbitrary constants; mechanical quadratures; secular and periodic perturbations; the stability of the system; the numerous lunar theories; periodic orbits; the discovery of Neptune; and so on. It is the romance of gravitation, which continues today in the discovery of Pluto, in the deviations of the moon, and in the wanderings of the earth's axis.

Observations. The system was really solved analytically before the era of accurate observations. Although eclipses three thousand years ago are used for determining secular accelerations in the longitudes of the sun and moon, and occultations since 1600 are used for the moon's longitude, observations of suitable accuracy for determining general motions were begun but two hundred years ago. Among those working more especially on the observations and the planetary and lunar tables may be mentioned Bradley, Gauss, Damoiseau, Bessel, Airy, Pontécoulant, Hansen, Adams, Leverrier, Delaunay, Gill, Newcomb, Hill, Cowell, and Brown.

As observations and tables multiply, the reductions become more

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laborious and changes in methods of computation have been noticeable. Leverrier gives an expansion of the perturbative function for planets that has 469 terms in it, and Brown's tables of the moon fill three volumes. Laplace, in referring to Napier's logarithms, says "An admirable artifice which, by reducing to a few days the labor of many months, doubles the life of the astronomer and spares him the errors and disgust inseparable from long calculation." For numerous classes of computation the modern multiplying machines are many times faster than logarithmic work. And still more recently the electric punched card machines are far outstripping the manual machines in speed and accuracy, as illustrated in the recent solution for Mercury of 4700 equations of condition with 11 unknowns in one-tenth the time it took by former methods.

When Herschel discovered Uranus (1781), Lagrange and Laplace were intensively studying the secular and periodic perturbations in the system. The great inequality in Jupiter and Saturn was finally solved by Laplace in 1784, and there is little doubt that, had Herschel not made his brilliant discovery, Uranus would have been found soon by its gravitational action on Saturn. Bouvard's tables of Saturn (1821), were accurate to some 20″, and Uranus disturbs Saturn by many times that amount.

The Tables. The observations of Bradley and his successors, together with a fairly complete theory for the important motions in the system, led to the construction of numerous tables for the planets and the moon soon after 1800. Lindenau's tables of the inner planets and Bouvard's tables of the outer planets were compared with the Greenwich Observations, 1750-1830, and the longitude residuals were found to vary some 40″ or 50″. These tables included quite a large number of periodic perturbations and some secular variations.

Neptune's discovery stimulated such work, and by the middle of last century, with some one hundred years of observations from Greenwich and Paris for determining elements and constants, Leverrier set to work and thoroughly revised the theories of all the planets and constructed accurate tables of their motions. These, with some revision, have been used in the French Ephemeris ever since. His tables of the sun appeared in 1856. About this time, 1857, Hansen developed tables of the moon's motion to an accuracy of 2″ or 3″, and his tables, with corrections by Newcomb in 1877, were the standard until 1923. A complete mathematical theory of the moon was worked out also by Delaunay at about the same time.

Observations of sufficient accuracy and numbers for more rigid determination of elements and constants commenced about one hundred years ago, with the installation at Greenwich, Washington, Pulkova, and elsewhere, of several large instruments, together with more accurate clocks, compensated for temperature and pressure, and improved

recording of transits on electric chronographs. And toward the end of the century Newcomb and Hill carried out exhaustive investigations of the theories of the eight planets and, using observations for 1750-1890, derived new elements, constants, and masses for the system. Extensive tables of motion were constructed, accurate as to theory to a few hundredths of a second of arc. The longitude of the sun, for example, contains some one hundred and fifty periodic terms. These came into general use about 1900, and will be the standard for years to come. Also, the theory of the moon was worked out in a most exhaustive research by Brown, and tables were constructed which are so nearly complete that about 1500 terms are required to give a single position of the moon. These came into use in 1923. Newcomb's tables contain empirical terms in the motions of the perihelia of the four inner planets; and Brown's longitude of the moon has an empirical term with a coefficient of 10″.71 and a period of 257 years. These terms have since been explained.

The beginning of this century found, therefore, a fairly complete solution of the complex gravitational motions of the planets and their satellites, together with tables of these motions, and good values of the general constants of the system. The theory thus established was complete, for the elements and masses adopted, to the second decimal of arc for the coordinates. In the fifty years since Newcomb's work, modern observations have accumulated to a weight far exceeding that of all the older observations used by him, and these observations make possible improved elements and masses and better values of such constants as nutation, aberration, solar parallax, etc. More accurate positions and motions of the fundamental coordinate planes of reference have been determined as more accurate positions and motions of the standard stars and the precession have become available. Discussions of the new observations are furnishing a better understanding of the deviations in the moon's longitude, now attributed to a fluctuation in the rotation of the earth; of the secular acceleration of the mean motions of the moon and planets due to tidal friction and other causes; and motions of the perihelia and the precession attributed to relativity effects. The theories of the outer planets are being revised to include Pluto, and corrections have been found to the tables of the inner planets and the moon. Some of these investigations may be considered briefly.

The Fundamental Coordinate System. The ecliptic and equator are convenient planes of reference, having stable motions, and they are used for the coordinate system. With proper allowance for perturbations, the motion of the sun along the ecliptic, or of any planet along its orbit, traces out a great circle which averages 90° from the pole of the equator. The points at which the polar distances of the sun are 90° are the equinoxes, and the variation of the polar distance from 90°, as at the solstices, gives the obliquity. The daily observations of the sun and

planets are necessarily referred to places of the standard stars among which they move, and the deviations of their positions as so observed from the conditions just stated give the equinox correction to the right ascensions of the standard stars, and the average correction to their declinations. The position of the pole of the equator among the stars is determined by observations of circumpolar stars in both right ascension and declination. With the two fundamental points in each coordinate, as just described, the stars are spaced out in right ascension by the sidereal clock, and in declination by the divided circle. The process is repeated over and over in order to determine the motion of the planes among the stars, the precession, and the nutation.

In this manner a fundamental star system is built up which defines the position of the equator and ecliptic from year to year. Such observations are now carried on continuously with the standard instruments at Washington, Greenwich, and Cape, and in shorter series at several other places. The day terms are studied by observing the brighter stars around the sun in the daytime. The day refraction is different from that at night, affecting the declination work; and diurnal terms and personal equations affect the right ascensions.

The equinox as determined for the clock stars depends upon the method of observing. To get the true right ascension of the sun using the old methods, eye and ear, or key and chronograph, the right ascensions of the clock stars must be 0".6 or 0".7 larger than those required when observing with travelling threads. Newcomb's equinox was correct for the observations he used. This difference has to be considered also in determining the motion of the equinox. Further, the average motion of the clock stars relative to the more distant stars is around 1".00 a century, so that the motion of the equinox referred to them differs from true precession. These matters have been discussed previously.[1]

Several determinations of the equinox have been made using modern observations of the sun, moon, and planets.[2,3] The different determinations agree closely and the right ascensions in the new fundamental catalogs FK3 and GC, based on them, are 0^s.05 and 0^s.04 less than those in the catalogs of 1900, and correspond to observations with travelling threads and freed from personal equation.

Similarly, using observations of the sun and planets, positions of the ecliptic and equator among the stars have been carefully investigated recently by Morgan[4] and Heineman.[5] The two determinations agree closely and the FK3 declinations are based upon them. These agree, also, with Newcomb's older system. The equatorial declinations of the GC, however, require a correction of +0".2, or more. The occultation results, 1680-1908,[6] uphold both the equinox and the equator determined from the sun and planets. Observations of asteroids are now being used by Brouwer[7] for determining the positions of the ecliptic and

equator among the stars. The main program extends over ten years and includes photographic observations of fifteen asteroids. Having the accurate positions of the stars and the coordinate planes, the observations properly space the planets along their orbits, and the deviations from tabular places may be used to correct the tables.

The Observer's Motion. Starting nearest home, it should be kept in mind that one of the most troublesome problems for the observer is to free his observations from the complicated motions of the earth where he observes. The latitudes and longitudes on the earth vary with the wanderings of the earth's pole of rotation around its pole of figure; the time unit changes with the variation of rotation of the earth; the zenith shifts progressively among the stars with precession, and in a complicated manner with nutation; the earth circles irregularly around the center of gravity of the earth-moon mass each month; and it is being continually pulled from its path by the perturbations of the planets.

The Variation of Latitude. The motion of the pole has two principal periods, one of 12 months and one of 14 months, the former in an ellipse of 0″.2, and the latter in a circle of 0″.4 in diameter. These terms have been found to vary both in amplitude and in period, in an irregular manner, such that no law has been found to predict the variation of latitude accurately. The only way observations may be corrected for it is by continuous observation with special instruments, and such observations are being carried on at twelve or more observatories, eight of which form an international net work. By this motion the nadir point of a transit circle may vary as much as 0″.6 in 14 months, and the azimuth of meridian marks may change even more. Hence on account of the importance of the data in determining absolute positions, the observatories at Washington, Greenwich, and Pulkowa maintain special observations for it. Much work of this kind has been done with zenith telescopes. The photographic zenith tube at Washington is proving an exceedingly accurate instrument for this purpose, the probable error of a latitude from one night's work being around ±0″.03. A similar instrument is being installed at Greenwich. The minute theoretical change in the level of the mercury with the hour angle of the moon, 0″.008, has been determined from the observations both on the Greenwich[8] and on the Washington[9] instruments. The Astronomer Royal, from a careful discussion of the results with the Cookson floating zenith telescope at Greenwich,[8] 1911-1936, finds diurnal terms in the observations, terms due to the direction of the wind, and terms due to earth tides and ocean tides. Similar terms have been found at Washington,[10] at Pulkova,[11] and in the international latitude observations.[12]

Jeffreys[13] and Rosenhead[14] show that known annual meteorological changes in the atmosphere, in snow fall, in vegetation, and in oceanic motions, are quite sufficient to explain the annual motion of the pole

and its irregularities. For instance, the change from the heavy snows of winter to the rarefied air of summer over the great Siberian plains is supposed to contribute appreciably to the annual term. They find, however, that the changes in the free motion are more difficult to explain. Decided changes in the period and amplitude of the 14-month term have been found by Dyson,[15] Jeffreys,[16] Markowitz,[10] and others. Lambert, Schlesinger, and Brown[17] give a summary of the history, observation, and theory of this motion. The free motion corresponds to the earth being twice as rigid as steel, and there is some evidence that irregularities in the motion of the pole are correlated with irregularities in the rotation of the earth. About 1923, for instance, the rotation appreciably speeded up, and the amplitude of the free polar motion became much smaller for a number of years. Changes occurred, similarly, about 1908. There were severe earthquakes at both epochs.

Lambert[18] found evidence for a secular shifting of the pole. Recent observations are rather against this. Orlov,[19] from the Pulkova observations, 1892-1938, finds the mean pole does not move; Markowitz,[10] from the Washington observations, 1911-1940, finds the mean latitude of Washington is constant; and Jones[8] finds the latitude of Greenwich changes less than 0″.1 in 25 years, and he further finds no certain evidence of changes in the relative longitude or latitude of any two places on the earth's surface.

The Fluctuation. In his investigation of the motion of the moon some seventy years ago, Newcomb found the observed longitude deviated at times 15″ or more from the computed value, and for this no gravitational explanation could be found. An empirical term of 15″ with a period of 270 years was introduced into the tables to take care of this. Newcomb suggested that such residuals would arise if the rotation of the earth were not uniform. Later, minor fluctuations were found, and these seemed to be correlated to deviations in the longitudes of the planets. De Sitter[20] and Brown[21] then found that the total fluctuation of the moon could be represented by a broken line indicating rather sudden and irregular changes in the phenomena. Brown pointed out that the sudden breaks enable one to eliminate gravitational sources exterior to the earth as a cause, for gravitational attractions are continuous forces. He concludes that one must look for the source well below the earth's surface, and proposes a world-wide alternate expansion and contraction ranging from a few inches to a few feet. The problem is largely geophysical and the progress made in its solution is not very satisfactory.

Innes, De Sitter, and Jones[22] have shown that there is a correlation between the fluctuation in the longitude of the moon and in the longitudes of Mercury, Venus, and the earth, and that these are approximately in the ratio of the mean motions—a necessary consequence if due to irregular rotation of the earth. It is now generally accepted that

the observed fluctuations in longitude are due largely to this cause. However, the question as to whether any part of the deviation is in the moon itself and is not correlated with the planets has been carefully considered. Brown[23] concluded, after a searching investigation for any defect in his theory, that the deviation of the moon from his gravitational theory must be taken as the true measure of a variable rotation, and a consequent variable time. The moon was 15″ ahead in 1785 and is now 20″ behind its computed place. This corresponds to a change of 0ˢ.001 to 0ˢ.002 in the length of the day, the apparent time varying on uniform time by 60ˢ a century.

Fotheringham,[24] among others, has made careful studies of ancient eclipses and, using his results, De Sitter[21] finds a secular acceleration of the longitude of the moon 5″ greater than that computed from known perturbations, and for the sun 2″ greater. Jones[25] shows that this excess is probably decreasing, as the last two hundred and fifty years are satisfied with smaller excesses. Jeffreys,[26] among others, finds the tidal friction in the seas sufficient to account for such changes through a slowing up of the earth's rotation, with consequent changes in the time unit. It is pointed out that the secular terms for the moon and sun are not at all in the ratio of their mean motions and therefore require additional explanation.

Jones concludes, "The fluctuations in the mean longitudes of the sun, moon, Mercury, and Venus are proportional to the respective mean motions of these bodies, and can be attributed to variations in the rotation of the earth caused by changes in its moment of inertia. The secular variations of the sun, Mercury, and Venus are proportional to their mean motions, and can be accounted for by retardation of the earth's rotation by tidal friction. The secular acceleration of the moon cannot be predicted theoretically because tidal friction causes changes in the orbit of the moon that are too small to be determined by observation. The observations of the sun and Mercury agree in indicating that the average effects of tidal friction during the past two hundred and fifty years are smaller than the average effects during the past two thousand years." For his tables, Brown adopted the theoretical secular acceleration, and an empirical periodic term 10″.71.

With tidal friction, or with this and other variable causes, the earth is not only slowing up, but slowing up irregularly. It therefore makes a difference over what period a time unit is adopted. De Sitter took a period 1750-1917. This corresponded to the period of observations discussed. The rotation has changed appreciably in the last twenty-five years. As the changes are irregular and entirely unpredictable it is essential that continuous observations of the sun, moon, and planets be maintained for evaluating these changes. The corrections to uniform or gravitational time are approximately as follows: 1785, +25ˢ; 1865, 0ˢ; 1900, —29ˢ; 1917, —19ˢ; and 1940, —36ˢ. De Sitter found that the

satellites give evidence of a retardation in the rotation of Jupiter, and the variable earth time had to be considered also in reducing the observations of these satellites.

The Astronomical Constants include also certain motions and elements of the earth. None of the quantities used below are proposed as substitutes for those now in use though in some cases they may prove to be better.

In the following equations are given observed values of the precessional constant, the nutation, and the lunar inequality. H is the dynamical flattening of the earth, $\pi\odot$ the solar parallax, and $\mu' = \mu/(1+\mu)$, where μ is the mass of the moon. The numerical coefficients are functions of the mean motions of the earth and of the moon, the rotation of the earth, the motion of the moon's node, and the lunar parallax—all of which are fairly well known, except possibly the last.

$$\begin{aligned} P &= 54''.9366 = [3.725076]\ H + [5.975060]\ \mu'\ H \\ N &= 9.207 = [5.402899]\ \mu'\ H \cos\epsilon \\ L &= 6.440 = [1.780075]\ \mu'\ \pi\odot \end{aligned}$$

The precession has been reviewed in a previous paper.[1] Wilson and Raymond[27] discussing the motions of 32,000 stars in the new General Catalog, and Oort[28] using fainter stars, both derive corrections of about +1".0 to Newcomb's centennial precession. And Vyssotsky[29] from the motions of 35,000 fainter stars finds a somewhat larger correction. For the dynamical relations De Sitter[30] adds +1".94 for the geodesic effect.

The nutation, 9".207, comes from four determinations: Newcomb,[31] 9".210; International Latitude, 1900-1915,[32] 9".207; Washington circumpolars,[33] 9".206; and the Greenwich latitude work 1911-1936, 9".2066. The International Latitude work since 1900 and the Washington latitude work need discussing for nutation.

The lunar inequality 6".440 comes from two different classes of observations, the sun and the asteroids. The sun, 1820-1864[34] and 1900-1937,[35] gave 6".456 and 6".450, respectively. These observations cover some five hundred lunations each as against the five lunations used on asteroids. The asteroid parallaxes are much larger and they are observed photographically at night so that accidentally the results are considerably more accordant. However, as compared with the large planets their mean motions and distances are rather poorly determined.

In 1931 the observations of Eros varied several seconds of arc from the positions computed definitively by numerical integration. The orbit was revised, but the residuals, in 1944, again vary 5". The Eros observations in 1901[36] gave 6".4305 and in 1931[37], 6".4378 for the lunar equation.

With $\pi\odot = 8''.795$ the last equation above gives $1/\mu = 81.305$, while the first two give $1/\mu = 81.865$. These are quite discordant. Following Newcomb, however, the three equations solved together give $1/\mu = 81.53$ and $H = 0.0032785$. These agree with values now adopted, and

when substituted in the equations give: P = 54".9154, N = 9".215, and L = 6".422. The agreement with the observed values is not satisfactory.

Jackson[38] and Brouwer[39] have discussed the inconsistency of these equations. The theoretical relations are given by Oppolzer and others, and they have been examined by Hill and by De Sitter, and more recently discussed by Jones and by Jeffreys,[40] but the figure, constitution, and dynamics of the earth and moon are not sufficiently known to give the dynamical flattening, H, which De Sitter takes as one of his fundamental constants, and which he asserts must come from the precession, as above.

Geophysicists are intensively studying the tidal friction in the seas, the ocean currents, and air masses, the seismic waves, gravity, isotasy, and the mean radius of the earth. This radius is a fundamental constant determined from measured arcs on the surface. The U. S. Coast and Geodetic Survey[41] has just completed an arc of 5400 miles, running from Bering Strait to southern Mexico, and an amazing geodetic network with 225,000 bench marks covering the whole of the United States, together with gravity determination at 1100 stations. Unfortunately, astronomers furnished poor star places for the astronomic work, with the result that this arc is too long by possibly 20 or 30 feet. This quantity may be insignificant, but the fact is not.

One of the most basic constants is the solar parallax, and the value as derived from a thorough discussion by the Astronomer Royal[42] from the observations of Eros, 1931, represents a remarkably consistent series of observations. The right ascensions give the same result as the declinations; the photographic as the visual; the subgroups taken in different ways are quite accordant. The computed probable errors are correspondingly unusually small. It might be noted, however, that all the results depend upon the one orbit of Eros, and this orbit did not satisfy the observed positions by several seconds of arc. The final parallax, 8".790, agrees with Newcomb's determination, but differs markedly from the Eros 1901 value, 8".8066, and from the value 8".8036 adopted by Brown. The parallactic inequality of the moon gives[43] 8".796, and the observed aberration 20".495 gives 8".795. It appears, therefore, that the value 8".800 in use since 1900 cannot be far wrong. Both Eros determinations were carried out with elaborate care and cooperation, and neither can be rejected. The two results differ by several times their probable errors, indicating that the systematic errors may be as large as the probable errors, and these mathematical errors become, therefore, unreliable for determining relative weights. This is not infrequently found to be the case in observational results.

The Sun. Newcomb's tables of the sun were not considered sufficiently rigid for the Eros work, and a numerical integration was made for the sun's position. This revealed small discrepancies in the tables, some of which have been explained by Clemence,[44] and by Williams.[45,78] The

discussion of the sun observations, 1750-1944,[46] shows that the eccentricity and longitude of perihelion of the earth require the corrections: Δe, —0″.12; and $\Delta \pi$, —4″.0; also that by replacing Newcomb's empirical term, 10″.45, by the relativity effect, 3″.8, in the perihelion motion the observed and theoretical secular variations agree. The sun's computed longitude thus requires an annual term, 0″.3, in addition to the fluctuation already discussed. There is no appreciable correction to the obliquity for 1900, but for the secular variation corrections are found as follows: sun and planet observations,[4] —0″.12; occultations,[6] —0″.30; Mercury solution,[66] —0″.25; and the mass of Venus, —0″.14.

The sun observations, 1900-1945, show other discrepancies requiring explanation. There is a persistent term in the longitude residuals of about 13 months period with an amplitude of 0″.05. There are terms in the tables of about this period, due to Venus, Mars, and Jupiter, but the effects cannot be separated. The quantities are rather too large to attribute to errors in adopted masses. The latitude residuals show two quite appreciable terms which are in Leverrier's tables but not in Newcomb's. A definitive discussion of all observations of the sun will be necessary before long, together with considerable examination and extension of the theory. The results of the recent reduction of Hornsby's observations of the sun and planets, 1774-1798, are valuable for determining the secular changes in the elements of the planets.

The velocity of light and a solar parallax 8″.795 give the aberration constant 20″.495. The Washington circumpolars[47] gave 20″.479; a spectroscopic value[48] is 20″.475; and the zenith results are: Greenwich[8] 20″.489, Pulkova[11] 20″.511, Washington[49] 20″.444, and Flower[50] 20″.526. However, diurnal terms have been found at several observatories, and these possibly affect the aberration determination from latitude observations. The value 20″.500 recommended by Newcomb appears, now, more likely than the value 20″.470 adopted by the Paris Conference and in general use since 1900.

The Moon. Besides the fluctuations of the longitude, other minor deviations have been found for the moon. An approximate comparison with Brown's tables of the observations, 1894-1923,[51] showed an annual term of 0″.5 in the longitude residuals, and similar residuals have been found since 1923, both for the meridian results,[52] and for the occultations.[53] It is shown that a large part of this is due to irregularities in the moon's limbs. The application of Hayn's corrections for irregular limb explains a large part of the annual term,[73] and also much of the 14-month variation in the latitude residuals found by Brown. Watts[54, 76] in continuing the investigation shows the importance of applying such corrections. A redetermination of the irregularities is much to be desired. In order to get the limbs at all librations such an investigation would extend over quite a number of years. The observed center of figure and the computed gravitational center of the moon differ in

latitude by about 0″.5.

An oblateness of the earth 1/294 was used in the theory, and the agreement of observed and computed motions of the node and perigee were not satisfactory. A few years ago, however, Brown[55] found terms of higher order that are appreciable, and these, together with relativity effects, bring the observed and computed motions into more satisfactory agreement. These are shown also to be in better agreement with the geodetic oblateness 1/297 now in general use.[56] The parallax of the moon from direct observations has received little attention. The Greenwich-Cape series should be repeated. A series in South America to compare with the Washington series would also be desirable.

The Planets. A definitive investigation of the motion of Mercury has recently been carried out, Williams[57] discussing the transits, 1723-1924, and Clemence[58] discussing the meridian observations, 1750-1937, and making an adjustment of the two results. Both investigations are definitive. The deviations in the longitude of Mercury are found to be closely correlated with the fluctuation in the moon's longitude, and the elements are derived adopting a variable time unit based upon the fluctuation. The sun's longitude was also corrected to this new time unit. The procedure is new in orbit work, and the authors point out that the moon's deviations may not by themselves represent the earth's rotation completely. The time unit used is, however, rigidly defined. The observed perihelion motion is found to exceed the computed gravitational motion exactly by the amount called for by relativity, both in the case of Mercury and in the case of the earth. The corrections to Newcomb's elements of Mercury are very small, and the authors conclude also that the theory of Mercury requires little or no revision. The transits give a larger mass for Venus; the meridian results, a smaller mass. The observed time of transit of Mercury over the sun's disc in 1940 is 18ˢ less than the computed time, and no explanation is found for this.

The observations of Venus need discussion, and Clemence and Scott[59] call attention to the need also of examining the observations of Mars. These latter have now been reduced to a uniform system and an ephemeris is required for comparing the older observations, including those by Hornsby, 1774-1784. The motion of Mars is important in determining the mass of Venus which is uncertain by possibly one part in two hundred. Several determinations[35] of this mass have been made recently, using the periodic perturbations in the longitudes of the inner planets and the secular perturbations of their elements. The value of the reciprocal of the mass varies from 402,000 to 410,000, with a mean about 406,000, which seems more probable than the value 408,000 now in use. A change of this amount would increase the centennial motion of Mercury's perihelion by 1″.0, and the secular variation of the obliquity by 0″.1. Also, the perihelia motions of Venus and Mars will probably be found to agree with the relativity effects rather than with the

empirical terms of the tables.

Hill was not entirely satisfied with the differences between observation and his theory for Saturn, the annual residuals in longitude amounting at times to 1″.0. The Washington, Greenwich, and Cape observations of Saturn and Jupiter, 1895-1945, taken in five-year means, give residuals varying from +0″.7 to —1″.3 for Jupiter and from +0″.4 to —2″.3 for Saturn. Those for Saturn have the period of the planet and correspond to a change of 0″.5 in the eccentricity.

The brighter satellites of Jupiter have been thoroughly discussed by De Sitter[60] and he considers the mass of Jupiter one of the best determined constants of the system, its mass 1/1047.40 being uncertain by four or five in the last figure given. The satellites of Saturn have been discussed by H. Struve and by G. Struve,[61] but there are many observations of these satellites not reduced. The mass from the different satellites varies considerably, and a more general discussion should be made. An extensive series of photographic observations of the satellites of Uranus and Mars would help to determine the masses of these planets. The definitive discussion of the observations of the satellite of Neptune, 1848-1923, by Eichelberger and Newton[75] gives a mass for Neptune agreeing with that used in the tables. The photographic and visual observations differ somewhat. The satellites of Mars have been discussed by Burton[74] and by Sharpless.[77] The latter finds evidence of secular accelerations in the longitudes. Observations and reductions are carried on continuously at the Naval Observatory but, on the whole, satellite observations and reductions are being neglected.

The asteroids have practically no influence on the motions of the planets, but Eros, and others, have been used to determine the solar parallax; Polyhymnia, and others, for the mass of Jupiter;[62] and Brouwer is using a number for determining positions of the ecliptic and equator.[7] Leuschner[63] gives a recent survey of work on these objects together with orbits for the first 1091 asteroids (1801-1929.5). Orbits for the asteroids are not definitive or fundamental as are those for the major planets. While general perturbations have been computed for over 200 and special perturbations for a great many more, these are in general computed from and applied to osculating elements which change so seriously with the time that little progress has been made in determining mean elements. Brown and Shook in their *Planetary Theory* give the theory of the Trojan group, the members of which have the same period as Jupiter and are found to oscillate around points 60° in longitude from Jupiter.

The observations of Uranus and Neptune have been reworked by Wylie and new elements of Neptune determined.[64] Brouwer[65] is revising the theories of these planets and is including the action of Pluto. A preliminary solution has been made using numerical integraton. With an inclination of 17°, Pluto's action on the latitude of Neptune has, in

the preliminary solution, given a better determination of the mass than the action in longitude. It has been shown before[66] that the longitude residuals of Neptune may be fairly well satisfied by small changes in its elements. At present the Pluto terms are not sufficiently separated from element terms in either the latitude or longitude equations.

The mean motion and distance of a planet can hardly be well determined until a number of revolutions have been made, and Neptune has as yet but part of one period. Pluto takes a thousand years to cover as much arc as Mercury covers in one year, or as Phobos covers in a day, and a poor orbit of Mercury would be derived from four revolutions. Pluto presents also a different problem from the bright planets in that it is too faint to refer directly to the standard stars. Its mass as now known approximates that of Venus. The elements will be uncertain for a few hundred years. Two orbits have been worked out using mechanical integration, one by Bower,[67] the other by Nicholson and Mayall.[68] The general theory of Pluto has been investigated by Rouré,[69] and Casco,[70] and here again theory outruns observation and numerical exactness. Small terms are found between Pluto and the other planets having periods of 10,000 to 20,000 years. The prediscovery work by Lowell and by W. H. Pickernig also deserves mention, as the discovery was the reward of many years of persevering search.

Sufficient examples have been given to show that several problems are presented. One is the geophysics of the earth, its size, shape, gravity, density, and general internal constitution, and its meteorological and tidal forces. Again, revision and extension of the planetary theories and tables must be undertaken. Also, much work is needed on the satellites. But more basically, more observations and more accurate observations of the sun, moon, and planets are required, and such observations should be continuous in long series at several different observatories and in both hemispheres. Observed longitudes of the sun at Greenwich and at Washington differ from each other at times systematically by as much as 1″.0. Such systematic errors must be reduced. Further, it has been found that observations of the sun are not sufficiently accurate to check coefficients of periodic terms in theory closer than 0″.02 or 0″.03. The two theories of Newcomb and Leverrier generally agree more closely than this. The burden of such observations falls on government observatories, but investigators everywhere are sharing in the reductions and in the theoretical problems.

There are appreciable uncertainties in the present tables and constants, but on the whole the system is good. It has been in use since 1900, and it is probably sufficient for several decades to come. After 50 years the unexplained residuals in the longitudes of the planets scarcely exceed a second of arc. Many difficulties and uncertainties have arisen in comparing theory with the observations of last century. There were many changes in the tables and reduction constants, and various

methods of reduction were used, so that the confusion and uncertainty in the results discourage the computer. Such changes are detrimental and no change whatever should be made in the present system until all of it can be revised and adjusted into a homogeneous system.

The three equations discussed above show important relations between twelve of the astronomical constants. No one constant can be changed without affecting many others. Newcomb[71] derives a solar parallax by adjusting the results from nine different sources, including several different kinds of observations, and involving numerous other constants. Harkness[72] makes a least squares adjustment for ten of the basic constants. De Sitter[30] finds the agreement between observation and the present system of constants "fairly satisfactory," and cautions that a revision should not be piecemeal, but should embrace the whole system. He defines the system by adopting eight fundamental constants with their basic theoretical relations, and some twenty derived constants with their relations.

One of the larger discordances is in the centennial precession used in the tables, which is nearly 2″.00 too small, the mean motions requiring a corresponding correction. As the constants are inseparable from the planetary elements a complete revision of the system will not be possible or necessary until toward the end of the present century.

But this in no way minimizes the importance of carrying on investigations of these various matters with the observations in hand, for all such results will be important in the final adjustment. Many investigations are complete in themselves, such, for instance, as the solar parallax from Eros, or the masses of the planets from satellite observations. Such phenomena as the fluctuation must be kept under continuous investigation, and the extensions of the planetary theories are problems worthy of independent study by any student.

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U. S. Naval Observatory, Washington, D. C.

MARS

Ruddy planet, out yonder you sway,
Forty million miles away,
Come yield up your secret
To a sister planet's people.
Schiaparelli, Pickering, and Lowell,
And others who have viewed you well,
Have they interpreted rightly,
Red star that glows so brightly?

Mars, world of frost and drouth,
What mean those parched deserts,
Those blue green spots and patches,
Those spider lines we call canals
Supposed meteoric scratches?
Have your people dug ditches
So straight and true,
Merely for us to view,
Or do they serve a useful end
To feed and nourish a teeming life
On fertile plain and desert land?

W. E. Duckwall.
Hillsboro, Ohio.

James Walter Fecker
Builder of Telescopes
March 4, 1891 - November 11, 1945

By CLYDE FISHER

During the past twenty years, Walter Fecker has had a large share in building telescopes and accessories for the great observatories of this country and for those located in other parts of the world, witnessed by the number of times his name appears in the roster of telescopes, Schmidt cameras, etc., in Dimitroff and Baker's new Harvard book on the subject.

J. W. FECKER IN HIS SHOP EXAMINING A QUARTZ GRAVITY PENDULUM.
(Photograph by Clyde Fisher, February 3, 1931)

It is difficult to realize that he is gone,—taken in the prime of an active life. He was born in Washington, D. C., March 4, 1891. His parents were Gottlieb L. Fecker and Emma Boecher Fecker of Carlsruhe, Germany, where his father owned a small factory engaged in the manufacture of telescopes and precision optical instruments. His mother's family was also engaged in optical work. Later Walter's father became chief designer and manager of the instrument department

for the Warner and Swasey Company in Cleveland, Ohio. Mr. Worcester Reed Warner has said that Mr. Gottlieb Fecker was their most faithful instrument manager for twenty-five years, and that the results they achieved were largely due to his ability, genius, and patience.

Walter graduated from Case School of Applied Science in 1912, where he studied under Professor Dayton C. Miller. Upon graduation he joined his father at Warner and Swasey, where he continued his training in optics for the next ten years under the tutelage of his father. As a part of his education his father took him to Europe to study optical plants there. Indicating his marked ability, and the confidence his father had in his work, Walter made the drawings, computations, and designs for the large telescopes of 1912 to 1922 while at Warner and Swasey. During this time he made the drawings for the 72-inch for Vancouver, the 60-inch for Argentina, the 36-inch for Steward Observatory of the University of Arizona, the 12-inch for Cornell, and the 69-inch for the Perkins Observatory of the Ohio Wesleyan University. At the time he left Warner and Swasey, the drawings for the 69-inch were completely made, ready to be traced. As is customary in such cases, this work was all credited to the firm for which he worked.

In 1915 he was married to Miss Corinne Baffa of New York City. In 1921 he established a business of his own, beginning with the manufacture of small optical instruments. Upon the death of Dr. John A. Brashear, he was invited to come to Pittsburgh to manage the Brashear plant with J. B. McDowell, Dr. Brashear's son-in-law, but he declined. In 1926, after the death of Mr. McDowell, he was again urged to take charge of this famous shop, and at that time he did take over, thus becoming the successor to these two makers of optical instruments.

Immediately he began work on the larger instruments, and in less than twenty years he completed a surprisingly long list of important instruments.

He ground the 69-inch mirror and made the other optical parts for Ohio Wesleyan, then the third largest telescope in use in the world.

For Harvard College Observatory he made a large number of instruments of various kinds, including the 61-inch reflector for Oak Ridge, and the 60-inch mirror which he refigured for Bloemfontein, South Africa. He also remounted the 24-inch Bruce photographic doublet for the Southern Station of the Harvard College Observatory at Bloemfontein.

For the Princeton University Observatory he remounted the 23-inch refractor and built the new dome, elevating floor, and other miscellaneous equipment.

For the Lick Observatory he made the 20-inch Ross lens, the largest in the world.

For the Cook Observatory of the University of Pennsylvania, Wynne-

wood, Pa., he designed and built the horizontal 15-inch refractor with siderostat.

He also designed and built the Copernican Planetarium for the American Museum of Natural History, the largest instrument of this kind in the world. This device is used in connection with the Zeiss Projection Planetarium, providing a most valuable supplement to these demonstrations. During the ten years since the Hayden Planetarium opened, it has given clear and impressive instruction to millions of persons.

Various instruments that he has built may be found in other observatories among them Yale University Observatory, U. S. Naval Observatory, Leander McCormick Observatory of the University of Virginia, Kirkwood Observatory of Indiana University, University of Illinois Observatory, Yerkes Observatory, Washburn Observatory of the University of Wisconsin, and Mount Wilson Observatory. Among the foreign countries for which he made optical instruments are: England, Holland, France, Russia, Australia, Canada, India, Argentina, China, Brazil, Cuba, and Mexico. Other instruments have gone to the Bureau of Mines, the Bureau of Standards, and the California Institute of Technology. Mr. Fecker made his contribution to the war effort by discontinuing his regular work and devoting his plant to war work.

When not engaged upon some difficult problem in optical design or construction, he greatly enjoyed tramping in the fields and woods, especially those of his own farm near Coraopolis, Pennsylvania. Here the writer has had the privilege of walking with him. He was a keen observer of the progress of the seasons as indicated by the flowers and trees. His delight in the delicate color and form of a little bluet flower would proclaim him a lover of beauty in nature. Another hobby was kodachrome photography, one of his favorite subjects being sunrises and sunsets, of which he made hundreds of superb natural color photographs. His thorough knowledge of optics and the radiation of the various colors of light made him independent of the photo-electric-cell meter. The position of his home on his hill-top farm provided him an unusual vantage-point for these photographs.

Although Mr. Fecker never sought honors or recognition, he prized very highly membership in the American Astronomical Society. Whenever possible he was present at its meetings and participated in them. He also was a member of the Royal Astronomical Society, and of the Case School Chapter of Sigma Xi.

Besides Mrs. Fecker, he is survived by two daughters, Helen (Mrs. John G.) Curry of Pittsburgh, Pa., and Ruth (Mrs. Frederic E., Jr.) Stevens of Atlanta, Ga., and four grandchildren, John G. and Barbara Curry and Ann and Walter Fecker Stevens.

Hayden Planetarium, American Museum of Natural History.

Observations of the Total Solar Eclipse by the "Princeton Party" and Volunteers

By JOHN Q. STEWART AND WILLIAM L. HOPKINS, JR.

PART II*

The overcast at Malta did not extend into southwestern Montana and Idaho. In response to a plea to amateurs for observations of the moon's shadow in the air,[7] we have received reports from 46 different parties, totalling 152 persons. Their approximate stations are shown in Figure 1. Where there were several groups close together, as at Portland, the region of Cascade, Idaho, and of Butte, the dots in the figure have been arbitrarily spaced to secure clarity of representation. This map was traced on two adjoining regional charts (1M, 2M) of the USCGS aeronautical series, Lambert projection.

Officials of the U. S. Forest Service who saw the article in *Sky and Telescope* kindly suggested that information could be distributed to lookout men and forest rangers. Mr. P. A. Thompson, of Washington, D. C., arranged for the cooperation of the District Rangers at Ogden, Utah, and Missoula, Montana. We prepared a mimeographed questionnaire, which was carried up the trails to mountain-top lookouts. As a result, stations numbered 5, 7, 10, 11, 13, 14, 15, 16, 17, 22, 24, 26, 27, 28, 29, 30, 34, 36 (Fig. 1) were staffed by employees of the Forest Service, including several women.

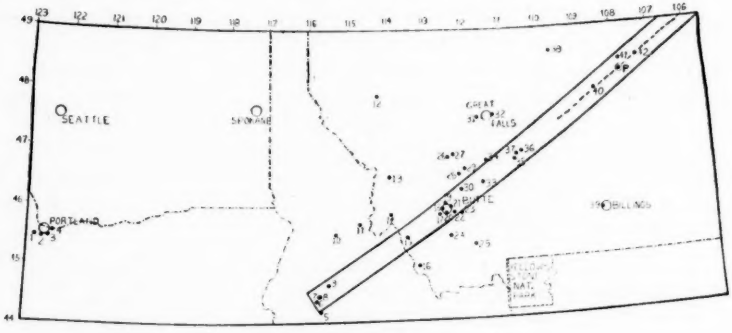

FIGURE 1

In addition, several hundred of the questionnaires, and other information, were broadcast by mail to addresses where it seemed likely that additional cooperation would be secured—to colleges, to county and city

*Part I in preceding issue.

[7] J. Q. Stewart, The Shadow of the Moon, *Sky and Telescope*, **4**, No. 7, pp. 3-6, May, 1945.

superintendents of schools, libraries, stations of the Weather Bureau, county engineers, Princeton alumni, etc., in northern California, southern Oregon, Idaho, Montana, and also to addresses in Saskatchewan. Nearly 30 completed reports were thus obtained, many of which are excellent.

So the early morning of July 9 found dozens of organized parties over a stretch of 1400 miles from California to Manitoba prepared to watch the moon's shadow in the air, to identify stars seen during totality, and to make other tests of the general illumination, for the purpose of preparing reports for the Princeton University Observatory. We cannot adequately express our gratitude to the individuals who so cordially and effectively cooperated in these thorough observations of the "falling shadow" at this sunrise eclipse. Some members of college faculties in Montana and elsewhere participated, relatively few of whom were trained in astronomy. Lawyers, ministers, farmers, forest rangers, business men, soldiers, sailors, and others became amateur astronomers for the hour of the eclipse. They watched from a variety of situations —mountain tops, airplanes, a tall city building.

Not a single "crank" report was received. The general level of the observations was surprisingly competent, and speaks volumes for the wide distribution in this country of interest in science. The moon's shadow came and went with tremendous rapidity, and the best of the observations of the shadow in the air probably equalled or excelled what any group of professional astronomers could have accomplished without elaborate instrumental equipment.

Table 3 identifies the various parties and will serve as a legend for Figure 1. We only regret that limitations of space do not permit inclusion of the name of every contributor.

Observations before Sunrise. By no means all of the participants enjoyed favorable weather. Mr. Renner writes that he took his post of observation "on a bale of fresh-cut hay," but found his view to the east completely obscured. It being out of the question to see the eclipse, "I went and milked my cow." It is especially unfortunate that Commander Mason in California had not a clear dawn, because this keen observer might have been one of those who detected the moon's shadow before sunrise in the upper air. We had made an attempt to enlist many observers in the sparsely settled country west of the sunrise point at Cascade, but received adequate reports only from the Portland stations.

There is strong evidence that the moon's shadow, like a dusky searchlight beam, was seen briefly from Portland, Oregon, before sunrise, and photographed, about the time when it descended to tangency with the earth 320 miles to the WSW near Cascade, Idaho. The moon's shadow, if it could be seen in interplanetary space, would always extend from the moon directly away from the sun, and its axis would appear to rotate around the sun in our sky. Exactly the same geometrical con-

ditions apply when the shadow reaches the earth's atmosphere. Even if the solid earth had been made of transparent glass the eclipse would not have been seen as total at Portland, although it would have been total at points well to the southward along the California coast. From Portland the moon's center would have passed a little to the right-hand of the sun's center. So the shadow in the air as seen there would have projected at first to the upper right of the sun and would have rotated down to the horizon. When very near the horizon it would have been harder to see because of increased opacity in the nearer air. Ordinary phenomena of twilight show that sun-illuminated air can be seen for many hundreds of miles into the night hemisphere, and it would be surprising if the moon's shadow were *not* visible before sunrise or after sunset at a total eclipse.

Mr. Carruthers states: "The sky was a bit hazy and we were looking for the sun to rise over some hills in the east. I turned to say something to Mr. Kimbrell when suddenly he pointed and said, what is that, and turning I too saw the dark shadow, a thin, clear edged, pencil thin streak, stretching out at an angle to the south, it seemed to broaden and fade out at the same time. This would be about 5:15 to 5:20 Pacific War Time, the shadow did not last very long, probably less than a minute." He reports that the altitude of the streak was about 5°, length about 5°, bearing 070 magnetic (variation 22° E).

Mr. Schminky sent us several feet of color motion-picture 16 mm. film which unmistakably shows the narrow streak in the eastern sky before sunrise, just as described by Messrs. Carruthers and Kimbrell, whose independent observations were made from a different station, Rocky Butte. These gentlemen are members of an amateur astronomical group. None was prepared to see the moon's shadow; and, very unfortunately, no one noted the exact time of the phenomenon. The shadow reached the ground in Idaho at 0513 Pacific War Time, and only 2 minutes later it had moved all the way across Montana. If the "pencil-thin streak" was indeed the shadow it must have disappeared at Portland by something like 0515 PWT. The time roughly estimated by the observers is not incompatible with this. Mr. Schminky's strip of film, made from Mt. Tabor Park, is too short to confirm or negate the theoretical rotation of the streak.

This motion picture was taken at 16 frames per second at stop f:1.9 with a one-inch lens on a Filmo Auto Load Speedster camera. The dusky streak appeared against a copper-colored sky. Mr. Schminky writes, "I had just turned my back to the skyline when I heard another man say, 'Look at that shadow.' I turned and looked for several seconds before I decided to try for a picture . . . I rewound and was debating about taking another shot when the shadow disappeared. So I do not believe the shadow was visible a half minute."

The Portland observation of the distant shadow is probably the most

original observation reported by any observer, professional or amateur, at this eclipse. Any test we have been able to apply fails to eliminate it. At future eclipses the shadow should by all means be watched for at stations far beyond the sunrise and sunset limits.

Professor Groening turned in a negative report from Portland: he saw no trace of the shadow, perhaps "because of some haze in the air." This seems to have been smoke from forest fires.

Observations near the Sunrise Point. Sunrise, as tabulated day by day in the *Nautical Almanac,* is defined as the instant when the sun's upper limb appears at the sea level horizon, normal atmospheric refraction being operative. But the sunrise limit at a total eclipse is defined differently, as referring to places where the sun's center at mid-totality is just on the sea level horizon, without allowance for refraction.[8]

Accordingly the upper edge of the sun would be seen above the horizon at mid-totality at points as far as about 55 statute miles westerly from the "limit." Similar considerations apply at sunset—mid-totality is visible up to 55 miles east of the limit.

We have reports from 5 parties (5, 6, 7, 8, 9) in the belt of totality near the limit in Idaho. No doubt this is the most carefully observed total-eclipse sunrise on record. At all but one of these stations good views were had of the shadow and the inner corona. Mr. Mann, who had climbed Warm Lake Summit, found that a higher ridge to the northeast hid the rising sun until totality had ended. The region is so hilly that the sea-level, or geometrical, horizon is there a mere ideal. Mr. Mann writes, "I will always regret that I didn't get up on Blue Point, but discretion shook his finger at me and told me I was too old to either hike up the mountain or wrangle a strange pack train alone."

Mr. Clayton Davidson, one of a party of 4 persons in a special airplane flight at an elevation of 11,500 feet, reports that, from that height near Cascade, totality occurred with the sun three diameters above the horizon. Looking for the moon's shadow in the air, he yelled to the pilot "There's your shadow!" "It appeared," he says, "as a truncated V." During totality it extended down across the sun with the blunted, or truncated, base at the horizon. It moved to the left as it receded, and was still visible in the air, he reports, as a truncated V to the left (N) of the sun after third contact.

This observation of a shift to the left is confirmed by Mr. Shaw (see next paragraph). Reference to Figure 1 shows that this means the retreating shadow must have been still visible in Idaho when it was pretty well across Montana. This in turn lends further support to the interpretation of the Portland observation as actually of the shadow. Mr. Davidson's report was transmitted through the courtesy of his former teacher, Professor S. A. Mitchell.

[8] Letter from Mr. G. M. Clemence, Director of the Nautical Almanac Office, 21 May 1945.

From a U.S.F.S. lookout station 10 miles S of Cascade, Mr. Shaw reports that the shadow was of a "light steel blue color." It appeared to be "of triangular shape" (of course an effect of perspective). It was first noticed in the southwest, and was seen travelling across the sky and over the sun. It then appeared to drop over the skyline first in the east, then farther north, shortening in its travel from south to north. Skies in this vicinity were clear, except for a very little cirrus at the horizon. Miss Scott first saw the shadow overhead, 4 seconds before second contact, slightly darker than the surrounding sky. Only the inner corona was reported by observers in Idaho, doubtless because of atmospheric extinction.

Mr. and Mrs. Mueller saw the shadow first at 180° from the sun. It swept across the zenith to the sun, and was colored a deep blue with the edges turned to grey. "I just had time to see the moon's shadow in west, follow it overhead, and then the sun came up totally eclipsed." Sky was lighted on both sides of the shadow. Shadow disappeared within a few seconds after third contact. Just before this it "seems to have arched from sun directly overhead through zenith toward west." One may suppose that the visible horizon toward the sun at this station was above the ideal geometrical horizon, since the sun was seen rising totally eclipsed.

Other Observations West of Butte. Stations 10 to 16, inclusive, are in this group. Of these only number 15 was in the belt of totality. Here Messrs. McClennan and Jackson report that the shadow in the air seemed as dark as the shadow "in a deep canyon at the break of dawn." It was first seen 5 seconds before second contact. They noticed that the sky, "gray and hazy" before and after totality, changed to a "clear blue" during totality. Except for the haze the sky was clear.

The Rev. Mr. Cameron (station 12) was 140 miles NW of the northern edge of the shadow belt. He did not notice the passage of the shadow, but there were some clouds there. Messrs. Greenup and Brown (station 11) who saw a heavy partial eclipse, report seeing the shadow to the SE. Five per cent of the sky was clouded, with cirrostratus, toward the east. They apparently are the first observers to report a new phenomenon related to shadow bands. The remaining narrow crescent of the sun seemed to flicker across the dark moon—there being a group of such images 4 to 12 in number passing at one time.

District-Ranger Warren and party (number 13) were about 50 miles NW of the northern edge of the total belt. Only 2 per cent of the sky was obscured, by cirrostratus, along the horizon toward the sun. They observed partial phases. The Rev. Mr. Gulick and Mr. Price, at Idaho Falls, 185 miles south of the central line (not on Fig. 1), had a clear sky, except for a thin line of clouds on the horizon to the west; but they noticed no trace of the shadow.

Observations near Butte. As Figure 1 shows, there was a good concentration of parties here. Stations 17 to 23, inclusive, were in the total belt. Number 17, staffed by District Forest-Ranger White and 4 others of the U.S.F.S. had an almost completely clear sky. Interesting photographs were made, and a splendid description of the moving shadow resulted from the visual inspection by these alert and out-of-doors-experienced observers. They saw the moon's shadow first as a circular spot almost at the zenith but off center a little toward azimuth S 45° W —"a circular spot of dark, blending into the surrounding clear sky. As the shadow descended, it widened, until it covered about half of the celestial meridian on an axis which would measure about S 45 W on a compass. As this shadow progressed from a spot to its widest coverage, it seemed to sweep down suddenly upon us with lightning rapidity. Toward the eclipsed sun there was a distinct band of dark shadow, much the same color as the shadow observed overhead, which extended to either side of the eclipsed sun about four lunar diameters" [*i.e.*, about 9 in all]. The shadow was "a very dark opaque bluish-gray." One had "the feeling of being engulfed" in it. "Suddenly the sun broke out of the shadow, which swept with suddenness in a N 45° E direction out of sight."

Professor Cooke, of the Montana School of Mines, (number 18) sketched the coronal streamers. To him the shadow appeared "gray to gray black." The unshadowed sky displayed "a general milky-whiteness with an underlying tone of red," and he had the impression that considerable light was received from it. Mr. and Mrs. Trask (20) observed independently from the same point as Professor Cooke, at 6750 feet elevation. Ridges of the Continental Divide formed the horizon toward the sun. There were cirrus clouds to the N, NE, and E, which were pinkish gray during totality, fading afterward to gold, then to white. Before this, as second contact rapidly approached, "shadows appeared in the valley below, as disconnected bands of shadow and light. . . The sky seemed to darken first at the zenith, and the darkness spread outward as the eclipse became total. . . The moon's shadow did not appear to race across the sky. Moving with a deliberate motion, from a nebulous gray mass into a truncated cone as it centered across the eclipsed sun, it had the texture and general appearance of a heavily laden rain cloud. This similarity was further accented by fringed edges that blended into the outer lighter-colored portions of the shadow. It had definite shape only for a few seconds. Before the shadow crossed the eclipsed sun it had started to assume a conical look, but this was approximately 20 seconds after the shadow was first observed to the south of the sun. Two bearings were taken after the shadow passed, which should give a fair estimate of the width of the darker conical portion of the shadow [as centered on the sun]—about 45°. Baily beads were seen at both contacts. The corona seemed white in color. The drop in

temperature at totality was noticeable.

Professor Livers (19) and the Montana State College party (from Bozeman) report seeing the shadow possibly two seconds before second contact, approaching like a thundercloud, somewhat purple in color. It was seen coming in the sky but not on the ground, like a giant cone extending toward the moon. Mountains to the north and south remained illuminated as the sky overhead turned dark and deep shade surrounded the party. The shadow was narrow, and the sky to the north and south was bright, but appeared deep purple toward the moon. The moon's shadow fell rapidly out of sight just after third contact. Shadow bands were clearly observed, but only briefly, near each contact.

Some of the parties near Butte did not see coronal streamers but others reported seeing them clearly, nothwithstanding the sun's slight altitude (3°). Professor Livers reports, "Perfectly white corona, very irregular, extending two-thirds to full solar diameter." Mr. Austin reports for an excellent group of 8 observers from Whitehall who were stationed on Bald Mountain. Some of this party saw "spokes" extending from the "ring of corona." They did not note the shadow before totality. It was triangular and broadening as it descended toward the horizon. During totality number 1 Jaeger type could be read fairly distinctly. Almost the whole sky was clear.

Mr. Edel, Mr. Richards, and three others formed another party (21) which carried out successful observations south of Butte. The sun rose over the Continental Divide. Just before totality, darkening overhead seemed to spread as the shadow descended. The edge was well defined as it approached the moon. During totality Mr. Richards noticed a dark area in the sky about 30° wide to right and left of the sun. Then the eastern horizon got brighter on each side of this area before third contact. Slight clouds on the horizon to the south were "rose-colored" during totality. When the sun's crescent reappeared, "the eastern horizon seemed instantly to become normal in light effects." It became light all around almost immediately. Prominences were seen through a 3⅛-inch refractor with power 96 during totality, and two groups of sun-spots on the uneclipsed sun. No Baily beads or shadow bands were seen. Two long coronal streamers were noted, about 180° apart. (Mr. Richards is the only observer of the many who reported at all stations who thought he saw a prominence with the unaided eye.)

It is splendid that the numerous competent parties near Butte enjoyed nearly perfect weather. A good color photograph of the moon's shadow in the air, showing the horizon-light and the corona, was secured by amateurs who flew to Butte from New York City.[9]

Forest-Supervisor Fry and Assistant Supervisor Linthacum (22) saw only the inner corona as a "relatively narrow ring of light around

[9] George Plachy and Peter Leavens, *Life Magazine*, **19**, (19) November 5, 1945.

the dark moon." District-Ranger Mass and Mr. Kore (24) apparently saw a heavy partial eclipse, with the inner corona visible "a general glow or narrow margin around moon."

Mr. Wilsey (Princeton, 1905) and party were 5 miles east of Virginia City (25), 45 miles from the southern edge of the total belt; the sky was almost cloudless. The shadow to the northward in the air was well seen "quite dusky and blue-gray and of a darker shade than the sky. Moved very rapidly. Outline very vague. . . We had a wonderful picnic breakfast afterward."

The meaning of "moon's shadow" was completely misinterpreted by several of the parties outside the total belt, who turned in good drawings of the partial phases showing the moon itself against the sun, but failed to watch for the shadow in the air. Except for the Portland observation that of the Wilsey party represents the most distinct view of the *passing* shadow—although there can be no question but that several parties saw the *retreating* shadow much farther off.

Observations East of Butte. Ranger Arthurs (30) reports that the moon's shadow vanished 2 seconds after third contact. Messrs. Hersey, Street, and Devan (34) were near the northern margin of the track of totality. They saw the shadow-edge above them in the air quickly bulge northward, and then retreat southward suddenly (as the ellipse of shadow passed) while the southern edge seemed comparatively static. The dark gray to blue shadow was clearly discernible on clouds and in the sky.

Party 33 comprised 22 persons. It was the largest one to report, and one of the best arranged. Dr. E. W. Neuman of Carroll College was the scientific leader and Honorable Fred Lay, Assistant Attorney General of Montana, was the organizer. Their report is one of those which could well be published separately in more detail. The moon's shadow in the air was first seen 5 to 7 seconds before second contact. It seemed "like a screen" moving across the sky over the sun and beyond toward the NE. Venus, Capella, and Altair (mag. 0.9) were identified, but not Saturn. The longest coronal streamers seen extended about three-fourths of the moon's diameter. Not more than a tenth of the sky was covered with scattered altostratus and cirrostratus. Photometer readings and photographs were made.

Use of these photometer readings was made in reaching some of the conclusions presented in Part I.[10] Photometer readings and star identifications reported by many of the parties have not been separately mentioned, but have been taken into account in preparing Table 2, Part I. In many cases it was reported that the second hand of a watch and ordinary newsprint could be read during totality.

Mr. Jennings (28) saw a "narrow shadow" to the south. Miss Furst

[10] J. Q. Stewart and W. L. Hopkins, Jr., *Popular Astronomy*, **53**, 482, 1945.

(29) reports seeing partial phases through clouds, and gives an interesting description of colors of the light. Mr. Lemmer (31) had "heavy black clouds" all around the horizon, but saw the shadow pass "as if a severe storm were approaching."

Sister Aimee, Mr. Pugsley, with a number of others observed from the roof of seven-story Columbus Hospital in Great Falls (32). Although this position was well northward of the total belt, they report that a definite "edge of color" was seen moving from SE to NW along a long finger of altocumulus cloud which itself lay from NE to N of their station, appearing 10 to 15 degrees above the horizon. This color required perhaps 7 seconds to move along something like 45 degrees of the cloud. Its edge was clear-cut and as if "a huge paintbrush" were leaving dark paint behind as it moved on the cloud. These observers, in response to a later letter of inquiry, indicate that they think they saw the moon's shadow on the cloud. But all the compass directions, reinforced with the careful diagram which they sent, are incompatible with that explanation.

The vicinity of Neihart, Montana, exercised an unholy attraction on three parties, all of which were clouded out (35, 36, 37). Captain Crawford, noted author of the Army Air Corps song, "flying high into the wild blue yonder," saw nothing this day. Mrs. Irvin and Miss Chambers at a U.S.F.S. lookout post at 8450 feet found that in spite of the clouds ordinary newsprint could be read, and the second-hand of a watch.

Mr. Evans and the three others of his party spent the previous night at a high elevation in the open, although totally unprepared for this. Seeking a suitable eclipse site, they had pushed their car too far on dubious mountain roads to return to the comforts of a hotel. After a shivering attempt at sleep they put out their campfire by shovelling snow on it. Clouds ruined the eclipse but left the wild flowers. "In nearly all the open spaces, the ground was a dense mass of the most brilliantly blue forget-me-nots. . . Through this mat 'shooting stars' were so thick that the red could be seen on hillsides three-fourths of a mile away. Here and there were a few white flowers. These patches of flowers, some over an acre in extent, were as brilliant as any of the pictures seen in gaudy magazines."

Mr. and Mrs. Gene Crawford and a group of employees of the Soil Conservation Service (41) were 16 miles NE of the Princeton expedition, but had heavier clouds. They were stationed on the 100 foot tower on the beautiful wildlife refuge.

The very well organized Montana State University eclipse party (42) near Saco were about 30 miles NE of the Princeton party, and had the same extraordinary luck of seeing the corona through a small window in the overcast. Mr. Hoffman reports that the shadow was first identified 10 to 15 seconds before second contact, to the westward. The edges of the shadow in the air could not be determined because of the over-

cast. After third contact, "moon's shadow could be seen on the eastern horizon for about a minute, giving it a dusty, dark appearance." Another gap in the clouds permitted this view to the ENE, which is recorded on a color photograph. One minute's motion of the shadow here would have been about 150 miles. Baily beads were noticed at second contact. As with the Princeton party, no one knew that ragged clouds had been close to the sun's limb until the photographs were developed.

From Canada we received two reports. Mr. A. W. Mills, who observed from Bradenbury, Sask., saw the shadow some 40 seconds before totality on the southwest horizon. (It was moving less rapidly eastward than in the United States.) It appeared mauve against the sky near the horizon and a similar but somewhat darker shade against the gray clouds. The shadow fell across the sky from the southwest, extended towards the sun rapidly, and was not seen on the eastern sky. It paled rapidly until it disappeared.

Mr. L. P. Coté and Miss Gilberte Coté observed near Montmartre, Sask., and their report includes the following comments:

"We observed the effect on the nature Animal. Hens craled under their roof. Birds reduced their Chirpin to Minimum. Horses in the nearby pasture were very dull and walked slowly in a southerly direction. Pidgeons also seemed to be tame. Temperature was about 33 above and no wind. Clouds clear the path of sun about 5 minutes before the commencement and conditions were ideal. From the top of the C. Nat. Ry. Loading platform it was a great sight."

Back in the United States another observer had noted the effect of the solar phenomenon on the birds. Mr. Shaw writes: "Just as it was getting dark, and before totality, some birds were observed to be flying along, and immediately settled to the ground. Their actions were as if they were forced to the ground by something above. They seemed to dive for the ground just a few feet beyond where we were standing."

Observations of a few of the parties have not been described here, either because weather was very unfavorable or because phenomena only of the partial eclipse were recorded. But every person who attempted observations is entitled to share in a feeling of gratification over the general success of the description of the sunrise fall of the moon's shadow. That this enterprise was conducted in wartime, while the loaded troop-trains were still roaring westward through Butte, Malta, and Regina, is additional cause for congratulation.

Data in advance were sent to Russian authorities, and it is not known whether a similar study of the rising shadow resulted at sunset in Turkestan.

TABLE 3

LIST OF STATIONS

Station Number	Position	Elev. ft.	Total No. in Party	
1	Portland, Oregon	600	2	H. J. Carruthers Mr. Kimbrell
2	Portland, Oregon	630	1	H. B. Schminky
3	Portland, Oregon		1	A. A. Groening
4	Troutdale, Oregon, 45° 32′ N 122° 25′ W	100	1	Frank Renner
5	Scott Mountain Lookout, 27 miles SE of Cascade, Idaho	8,268	3	Helen A. Scott Laura E. Scott O. F. Cusick
6	8.5 miles SE of Cascade, Idaho (in airplane)	11,500	4	Clayton Davidson Charley Davidson Donald Davidson Bill Wood
7	10 miles SE of Cascade, Idaho 44° 27′ N, 115° 57′ W	7,600	1	William H. Shaw
8	East Mountain Lookout Station 44° 27′ N, 115° 57′ W	7,500+	2	Mr. and Mrs. Frank A. Mueller
9	Warm Lake Summit, 44° 39′ N, 115° 35′ W	7,000	1	Karl L. Mann
10	Rabbit Point, 45° 30′ N, 115° 23′ W	6,300	2	Paul H. Strand Vern A. Layton
11	Magruder Ranger Station, 39 miles SW Darby, Montana	8,200	2	Stanley Greenup J. W. Brown
12	Rollins, Montana on west shore of Flathead Lake	2,900	1	Rev. E. R. Cameron
13	46° 30′ N, 114° W	8,400	4	J. W. Warren
14	Sula Ranger Station, Sula, Montana, 45° 52′ N, 113° 43′ W	7,105	1	Anna Vee Mather
15	O'dell Lookout, 12 miles SEE from Wisdom, Montana	9,446	2	Floyd E. McClennan Bob Jackson
16	Horse Prairie Ranger Station, 26 miles W of Armstead, Montana	6,500	2	Harold H. Hendron W. J. Neidt
17	Fleecer Ranger Station, 45° 50′ N, 112° 40′ W	6,300	5	Eric P. White E. J. Nordgaard
18	6 miles SW of Butte, Montana 45° 56′ N, 112° 36′ W	6,600	1	Strathmore R. B. Cooke
19	6.3 miles SW of Butte, Montana 45° 55′ N, 112° 36′ W	6,625	5	Professor J. J. Livers Dean F. B. Cotner
20	Near Butte, Montana, 45° 55′ N, 112° 36′ W	6,750	6	Frank Trask Anne Blake Trask
21	5 miles SW of Butte, Montana	6,000+	5	Peter Edel Alton F. Richards
22	S 40° E 14.5 miles from Butte, Montana	6,000	2	W. E. Fry V. T. Linthacum
23	Top of Bald Mtn., 11 miles W of Whitehall, Montana	6,190	8	Roy M. Austin Dr. Hill Dr. Kay
24	45° 27′ N, 112° 29′ W	9,000	2	Fred H. Mass George Kore
25	5 miles E. of Virginia City, Mont.	7,000	7	Mr. and Mrs. James A. Wilsey
26	Granite Butte Lookout Station 46° 52′ N, 112° 29′ W	7,600	1	H. L. McIlhattan
27	Liverpool Point	....	1	R. O. Fitzgerald
28	10 miles SW Helena, Montana	7,230	1	Jim Jennings
29	Strawberry Butte Lookout Station, Helena, Montana	....	3	Miss Garna Furse Wilda Allen Estella Allen

Station Number	Position	Elev. ft.	Total No. in Party	
30	2 miles NW of Boulder, Montana	5,800	4	A. J. Arthurs
31	18 miles west of Great Falls, Montana, 47° 29′ N, 111° 40′ W	3,500	3	Carl Lemmer S. N. Lenz T. R. Casaden
32	47° 31′ N, 111° 15′ W	3,330	11	Sister Aimee Bob Pugsley
33	6 miles SE Winston, Montana, 46° 23′ N, 111° 34′ W	3,749	22	Dr. E. W. Neuman The Honorable Fred Lay
34	18 miles ENE of Helena, Montana	7,816	3	Henry F. Hersey James E. Street William V. Devan
35	Near Neihart, Montana (in airplane)	....	1	Capt. Robert M. Crawford, USAAF
36	6 miles SW of Neihart, Montana, 46° 50′ N, 110° 33′ W	8,450	2	Mrs. Mabelle L. Irvin Blaine E. Chambers
37	Kings Hill south of Neihart, Mont.	7,950	4	Don C. Evans Cecil H. Smith
38	Havre, Montana, 48° 34′ N, 109° 40′ W	2,488	2	Frank A. Math Ann C. McNulty
39	Billings, Montana, Municipal Airport, 45° 48′ N, 108° 32′ W	3,570	6	W. J. Fitzgibbons H. C. Rinard W. H. Flanze
40	2 miles E of Zortman, Montana	....	1	Cecil Fletcher
41	Bowdoin National Wildlife Refuge, 7 miles E of Malta, Montana	2,325	6	Mr. and Mrs. Gene Crawford
42	South of Saco, Montana, 48° 26′ N, 107° 21′ W	2,400	6	Bernard Hoffman Dr. H. Chatland

The following are not within the limits of the chart.

Redondo Beach, California	....	1	Commander William A. Mason, USN (Retired)
1 miles from Idaho Falls, Idaho 43° N, 112° W	4,708	2	Rev. Joseph I. Gulick Mr. O. O. Price
1.1 miles NW of Bredenbury, Sask., Canada	....		A. W. Mills
84 miles north of the American Boundry, Montmartre, Sask., Canada	....	2	L. P. Coté Miss Gilberte Coté

A report by letter was received from Mr. R. P. Reckards of observations made near Belt, Montana.

PRINCETON, NEW JERSEY, NOVEMBER, 1945.

Astronomical Phenomena for 1946

By G. BRUCE BLAIR

The American Ephemeris and Nautical Almanac gives a remarkable amount of detailed tabular data with regard to the heavenly bodies, much more than any individual, either professional or amateur astronomer, has occasion to use. As an example: Many pages are devoted to accurate positions of the moon for every hour of the year and many others to lunar occultations, in addition to lunar phases, ages of the moon, times of rising and setting, complete data for the physical observation of the moon, etc. The one suggestion for improvement that the writer would offer is that the directions for the use of tables, at the close of the volume, might well be considerably expanded. This would save much time for users of the *Ephemeris*.

As in past years, a summary of items of general interest, largely culled from *The American Ephemeris*, is here presented for the year 1946.

Eclipses

The number of eclipses in 1946 is six, only one less than the maximum possible number for any calendar year. All of the four eclipses of the sun are partial and only one of them is of interest in continental United States.

Eclipse of January 3. This eclipse occurs largely over the Antarctic ocean, beginning near the southern tip of South America and ending South of Australia. Maximum magnitude, 0.55.

Eclipse of May 30. A partial eclipse which covers the South Atlantic Ocean from near New Zealand to the southern coast of South America. Maximum magnitude of eclipse on the antarctic circle southwest of South America, 0.89.

Eclipse of June 29. Maximum phase of only 0.2 near Archangel, Russia, on the Arctic circle. The eclipse extends from Oslo, Norway, to near the Mackenzie river in northern Canada.

Eclipse of November 23. (See Figure 1). A partial eclipse which covers the most of North America, except the region west of a line running from about the Oregon-California border to the southern tip of Texas. In the northwestern coast

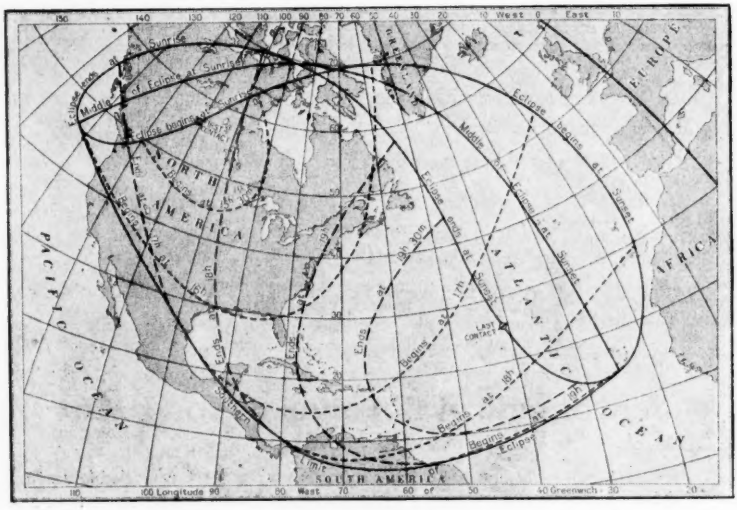

Figure 1
Partial Eclipse of November 23, 1946.
(The hours of beginning and ending are expressed in Greenwich Civil Time.)

states the eclipse will reach a magnitude of about 0.1. The northeastern and eastern states will fare better with magnitudes around 0.5 to 0.6. The middlewest gets from 0.3 to 0.4 and the southern states an average of about 0.3.

For the northwestern states the eclipse lasts from about 8:00 A.M. to 9:00 A.M., for the middle-west from 9:30 to noon, for the eastern states from 11:00 A.M. to 2:00 P.M., and for the southeastern states from 11:00 A.M. to 1:30 P.M. All times are in appropriate standard times for the regions mentioned. From Figure 1 the reader may determine approximate Greenwich times of the beginning and end of the eclipse for his location.

Lunar Eclipse of June 14. This eclipse will be observable, in whole or in part, in Europe, Asia, Africa, and eastern South America.

Total Lunar Eclipse of December 8. An eclipse which will be visible in the northwestern part of North America and, in general, in the entire eastern hemisphere. It is apparently not observable in continental United States but only in Alaska and our island possessions.

Lunar Occultations

1946 is an unusually poor year for occultations of planets and bright stars. Planets occulted for observers somewhere on the earth are Mars, Venus, and Uranus. Of these, only Venus and Uranus are listed as occulted in the United States.

Washington, D. C., Uranus, December 7, about 5:30 P.M.

Massachusetts Standard Station, Uranus, December 7, about 5:30 P.M.

Standard Station, Western Illinois, Uranus, October 14, about midnight; Uranus, December 8, about 10:20 P.M. (Emersion only).

California Standard Station, Venus, June 1, 3:40 P.M.; Uranus, October 14, 9:40 P.M.

All times are standard times for the region in question. No first magnitude stars are occulted during the year anywhere on the earth.

The Planets

The approximate local times of rising, meridian passage, and setting of the planets Mars, Jupiter, and Saturn are given in the following table. These will be roughly correct standard times if the observer is near the standard meridian for his time zone. If he is east of the meridian, the standard time at which the event occurs is earlier than that of the table by 4 minutes for each degree of longitude. If he is west of the meridian, a similar correction must be added to the local time given.

The local times of sunrise and sunset are convenient for determining whether the planet is above the horizon at sunset or sunrise. All times are calculated for latitude +40° and mid-United States. They will give an approximate idea of the conditions for anywhere in the country.

A further check on the planets observable at any time is given by Figure 2. When one of the planets, Mars, Jupiter, or Saturn, crosses the central vertical line of the chart from left to right, it is passing the sun from east to west and will appear in the morning sky and become a morning star. A few days later it will ordinarily be visible near the eastern horizon just before sunrise. As the days pass, the planet will rise earlier and earlier until finally it is 12 hours west of the sun, near opposition, rising then within an hour or two of sunset, crossing the meridian at midnight, and setting within an hour or two of sunrise. It then becomes an evening star (passing into the left hand side of the figure) setting earlier and earlier in the night until finally it will be found, shortly after sun-

TABLE OF TIMES OF RISING AND SETTING OF MARS, JUPITER, AND SATURN

Date	Sun-rise	Mars Ris-ing	Mars Merid-ian	Mars Set-ting	Jupiter Ris-ing	Jupiter Merid-ian	Jupiter Set-ting	Saturn Ris-ing	Saturn Merid-ian	Saturn Set-ting	Sun-set
Jan. 1	7:22*	5:50†	1:20*	8:50*	1:20*	6:50*	0:30†	5:40†	1:00*	8:10*	4:45†
Jan. 15	7:20	4:30†	0:10*	7:40*	0:30*	6:00*	11:30*	4:30†	11:50†	7:00*	4:59
Feb. 1	7:10	2:50†	10:30†	6:10*	11:30†	5:00*	10:30*	3:20†	10:40†	6:00*	5:18
Feb. 15	6:54	1:40†	9:20†	5:00*	10:30†	4:00*	9:30*	2:20†	9:40†	5:00*	5:35
Mar. 1	6:35	0:50†	8:30†	4:00*	9:40†	3:10*	8:40*	1:20†	8:40†	4:00*	5:51
Mar. 15	6:13	0:10†	7:40†	3:20*	8:40*	2:20*	7:40*	0:30†	7:50†	3:00*	6:06
Apr. 1	5:46	11:30*	7:00†	2:20*	7:20†	0:50*	6:30*	11:20*	6:40†	2:00*	6:23
Apr. 15	5:24	11:00*	6:20†	0:30*	6:10†	11:50†	5:30*	10:30*	5:50†	1:00*	6:37
May 1	5:01	10:40*	5:50†	1:10*	5:00†	10:40†	4:20*	9:30*	4:50†	0:10*	6:54
May 15	4:45	10:20*	5:20†	0:30*	4:00†	9:40†	3:20*	8:40*	4:00†	11:10†	7:07
June 1	4:34	10:00*	4:50†	11:50†	2:50†	8:30†	2:10*	7:40*	3:00†	10:10†	7:22
June 15	4:30	9:40*	4:30†	11:10†	1:50†	7:30†	1:10*	6:50*	2:10†	9:20†	7:30
July 1	4:36	9:20*	4:00†	10:30†	0:50†	6:30†	0:10*	6:00*	1:10†	8:30†	7:33
July 15	4:43	9:10*	3:30†	10:00†	Noon	5:40†	11:20†	5:10*	0:30†	7:40†	7:28
Aug. 1	4:55	9:00*	3:10†	9:10†	11:00*	4:40†	10:20†	4:20*	11:30*	6:40†	7:16
Aug. 15	5:11	8:50*	2:40†	8:40†	10:20*	3:50†	9:20†	3:30*	10:40*	5:50†	6:58
Sept. 1	5:26	8:30*	2:20†	8:00†	9:20*	2:50†	8:20†	2:40*	9:40*	4:50†	6:33
Sept. 15	5:40	8:20*	1:50†	7:20†	8:40*	2:10†	7:40†	1:50*	8:50*	4:00†	6:10
Oct. 1	5:54	8:10*	1:30†	6:50†	8:00*	1:20†	6:40†	0:50*	8:00*	3:00†	5:44
Oct. 15	6:09	8:10*	1:10†	6:20†	7:00*	0:30†	5:50†	Mid-N	7:10*	2:10†	5:22
Nov. 1	6:28	8:00*	1:00†	5:50†	6:30*	11:40*	5:00†	11:00†	6:00*	1:10†	4:59
Nov. 15	6:44	8:00*	0:40†	5:20†	5:50*	11:00*	4:10†	10:10†	5:10*	0:10†	4:41
Dec. 1	7:02	7:50*	0:30†	5:10†	5:00*	10:10*	3:20†	9:00†	4:10*	11:10*	4:35
Dec. 15	7:15	7:50*	0:20†	4:50†	4:20*	9:20*	2:30†	8:10†	3:10*	10:10*	4:36
Dec. 31	7:22*	7:30*	0:10†	4:40†	3:30*	8:30*	1:40†	7:00†	2:00*	9:10*	4:44†

*—A.M.
†—P.M.

set, low in the western sky. The behavior of Venus and Mercury will be explained in following paragraphs.

Wherever two lines representing two planets cross those planets are in conjunction.

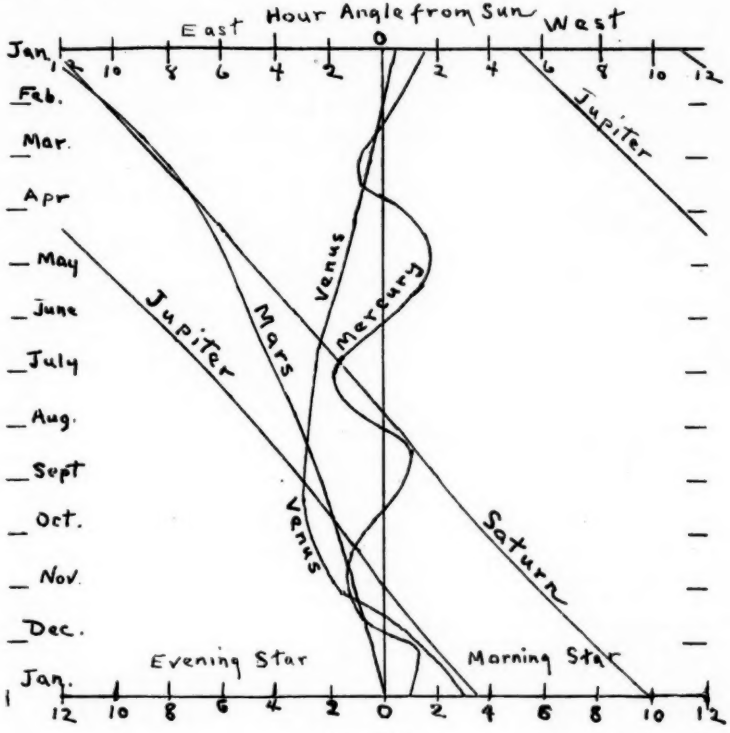

FIGURE 2

Mercury. A reference to Figure 2 shows that this planet weaves back and forth across the position of the sun, appearing alternately in the evening and in the morning sky. The times of greatest elongation from the sun are given in Eastern Standard Time.

March 9, 11:00 A.M., East 18°.3 (Evening sky).
April 23, 4:00 A.M., West 27°.3 (Morning sky).
July 5, 2:00 P.M., East 26°.1 (Evening sky).
August 20, 3:00 P.M., West 18°.5 (Morning sky).
October 31, 5:00 A.M., East 23°.7 (Evening sky).
December 9, 4:00 A.M., West 20°.9 (Morning sky).

The difference in longitude between the sun and Mercury at the time of each elongation is given. If at the time of elongation, the ecliptic lies at a small angle with the horizon, the altitude of the planet is not great, even for a large elonga-

tion. Unfortunately, this is true for the large elongations of April and October and the one in July is not unusually favorable.

Venus. The planet Venus passes the sun into the evening sky on February 1, reaches a position of greatest elongation (46°3) on September 8, and again passes into the morning sky on November 18. For the northern hemisphere, this elongation is an unusually unfavorable one. For latitude +40°, the altitude at sunset when the planet is at greatest elongation is only about 16°. A favorable conjunction of Venus and Mercury takes place on November 1 when Mercury is not far from eastern elongation. As shown by Figure 2, Venus has a number of conjunctions with other planets during the year, the most of them fairly near the western horizon.

The Earth. The Earth will be nearest the sun on January 2, at 1:00 P.M., and farthest from the sun on July 3, at 6:00 A.M.

Spring begins March 20, $0^h\,33^m$ A.M. (Sun at vernal equinox).

Summer begins June 21, $7^h\,45^m$ P.M. (Sun at summer solstice).

Autumn begins September 23, $10^h\,41^m$ A.M. (Sun at autumnal equinox).

Winter begins December 22, $5^h\,54^m$ A.M. (Sun at winter solstice).

All these times are Eastern Standard Times.

Mars. The red planet, Mars, will be closest to the earth on January 11, at a distance of 59 million miles, and will be in true opposition on January 14. This is a very unfavorable opposition, in fact about as unfavorable as can be. In December, 1943, the distance was 50 million miles and in October, 1941, only 38 million miles. For the sake of comparison, the diameter of the disc at the present opposition is only 0.65 of the diameter at the opposition in 1941.

At the time of opposition, Castor, Pollux, Mars, and Saturn will form a curved row of bright objects with Castor at the northern end. Diameter of the disc of Saturn will be 9¼″ as against 14″.5 for Mars, but the overall diameter of Saturn's ring system, 45″.6, is about 3 times the diameter of the disc of Mars.

The maximum magnitude of the planet Mars at this opposition is only —1.2 or 0.4 magnitude fainter than Sirius.

Referring to the table of data on Mars, we see that the center of the visible disc will be about 8° north of the equator of Mars at the time of closest approach. This means that the *north* polar cap will be tilted slightly towards the earth. The sun will be well beyond the vernal equinox for the northern hemisphere of the planet and the cap should be decreasing in size.

The following table makes it possible to find the latitude and longitude of the center of the disc for any time of observation covered by the table. Knowing the position of the center of the disc, it should be possible to identify any outstanding marking on its surface, provided that one has available a map of Mars showing latitudes and longitudes. Such a map is reproduced in the January, 1941, number of POPULAR ASTRONOMY. In using maps of Mars, note that the face of the planet turned towards the earth is moving from east to west, as seen in the sky and the value of the longitude of the center of the disc is continually increasing. However, from the point of view of a man on Mars, it is rotating from west to east (in the same direction as the rotation of the earth). The maps of Mars show the planet inverted, as seen in a refracting telescope, with the north at the top. The apparent direction of rotation is then towards the left which is therefore marked *east.*

To find the longitude of the center of the disc at 10:00 P.M., Eastern Standard

Time, for any date intermediate between those given in the table, multiply the change per day of the longitude of the central meridian which is opposite the nearest preceding date by the number of days that the required date is later than the date in the table. *Subtract* this product from the longitude of the date of the table. If the product is larger than the table value, add 360° to that value before subtracting. For a later or an earlier hour, add to or subtract from the longitude for 10:00 P.M. 14°.6 for each hour that the time is later or earlier than 10:00 P.M.

Observers in Central Standard Time should calculate the longitude of the center of the disc for an Eastern Standard Time one hour later than their own standard time of observations, those in Mountain Time for two hours later, and those in Pacific Time for three hours later.

Almost perfect atmospheric conditions are essential to seeing markings upon the surface of the planet especially with such a small disc as is presented at this opposition. If the planet is observed on every available night near the time of opposition, persistence may be rewarded with worthwhile results.

Note. Near the time of opposition the meridian of longitude of the planet which passes through the center of the disc will be tilted at an angle of about 12° to the true north-south line in the sky with its north end to the west of that line.

DATA ON OPPOSITION OF MARS FOR 1946

Date	Magnitude of Mars	Latitude of Center of Disc	Longitude of Center of Disc 10:00 P.M. E.S.T.	Daily Decrease of Longitude
Dec. 31	−1.0	9°.9	146°.5	8°.76
Jan. 10	−1.2	8.2	58.9	8.75
Jan. 20	−1.1	6.6	331.4	8.81
Jan. 30	−0.9	5.3	243.4	8.92
Feb. 9	−0.6	4.5	154.2	9.04
Feb. 19	−0.3	4.4	63.9	9.15
Mar. 1	0.0	4.8	332.4	9.25
Mar. 11	+0.2	5.6	240.0	9.34
Mar. 21	+0.4	6.7	146.6	9.40
Mar. 31	+0.6	8.1	52.6	

Jupiter. This planet has been lagging behind Mars and Saturn in coming into position for easy observation in the evening hours. On February 1, it will be rising at about midnight and opposition will take place on April 13 when Jupiter will be of magnitude −2.0 and have an equatorial diameter of 44".2. Thus a magnifying power of only about 40x will make it appear as large as the full moon to the naked eye. Throughout the observing season of 1946, satellite IV (Callisto) will pass to the south of the disc of the planet when on the farther side of its orbit so that it will be neither eclipsed nor occulted. Jupiter will be in conjunction with Venus on September 3 and with Mars on September 24.

Saturn. This planet and Mars have been fairly close together in the sky for many months. Saturn is in opposition on January 12, only two days before the opposition of Mars. After their conjunction of March 18, the two planets will begin to separate, Saturn passing the sun in late July and Mars not reaching conjunction with the sun until the end of the year. Saturn is quite favorably located for observation in the early part of the year with a declination of +22° at opposition. A diagram of the ring system for the opposition of this year is given as Figure 3.

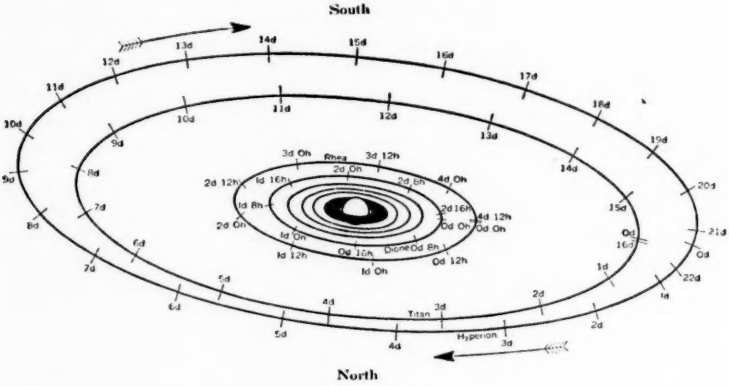

FIGURE 3

NAMES OF THE SATELLITES	APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, AT DATE OF OPPOSITION, JANUARY 12, 1946, AS SEEN IN AN INVERTING TELESCOPE.	MEAN SYNODIC PERIODS
I. Mimas		I. 0 22.6
II. Enceladus		II. 1 8.9
III. Tethys		III. 1 21.3
IV. Dione		IV. 2 17.7
V. Rhea		V. 4 12.5
VI. Titan		VI. 15 23.3
VII. Hyperion		VII. 21 7.6
VIII. Iapetus		VIII. 79 22.1
IX. Phoebe		IX. 523 15.6

Uranus and Neptune. Except at the times when these planets are passing some fairly conspicuous naked eye star, they are rarely observed unless the observer has setting circles on his telescope. Such observers usually have full data available in *The American Ephemeris.* The times when the planets may be easily identified will be given later in the monthly notes on the planets.

University of Nevada, Reno, Nevada.

The Planets in February, 1946

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time 6 hours, etc. The phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. The sun will move northward from —17° 20′ to —8° 16′ during this month. It will pass from Capricornus to Aquarius.

Moon. The phases of the moon will occur as follows:

		d	h
New Moon	February	2	5
First Quarter		9	4
Full Moon		16	4
Last Quarter		24	3

The moon will be at perigee on February 9 and at apogee on February 23.

Mercury. At the beginning of the month, Mercury will be a short distance west of the sun and will be moving eastward quite rapidly. On February 11 it will pass the sun on the side opposite from the earth. At the end of the month it will be less than an hour east of the sun and hence will remain invisible throughout the period.

Venus. Venus will be directly on the opposite side of the sun from the earth on February 1. This position is called superior conjunction. It will move eastward more rapidly than the sun and become an evening star. However, even at the end of the month it will be too near the sun to be seen easily.

Mars. Mars will continue to move westward slowly in Gemini. It will be above the horizon practically all night. It passed opposition on January 14, but did not come very close to the earth. It is now receding from the earth.

Jupiter. Jupiter will move very little during the month. It will be very brilliant in the morning sky, near the bright star Spica.

Saturn. Saturn will move westward slowly in Gemini, in the same part of the sky as Mars. These two planets will continue to be an interesting pair of objects for observation and study during February.

Uranus. Uranus will move a few degrees south in Taurus. It will be favorably situated for northern observers in the early evening.

Neptune. Neptune will be visible in the morning sky not very far from Jupiter during this month.

Occultation Predictions for February, 1946

(Taken from the *American Ephemeris*)

Date 1946	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′										
Feb. 8	64 Ceti	5.7	0 19.2	—0.7	+2.2	15	1 7.4	—1.4	—2.4	290
11	ι Taur	4.7	1 13.1	—1.3	+4.5	16	1 51.1	—2.0	—4.4	318
11	330 B.Taur	6.3	1 29.1	—2.0	—1.2	106	2 38.4	—1.6	+0.8	231
11	105 Taur	6.0	3 37.3	—1.5	+0.8	44	4 30.3	—0.5	—2.6	304
12	1 Gemi	4.3	0 35.5	—1.8	+0.8	79	1 56.0	—1.9	0.0	265
12	3 Gemi	5.8	3 58.4	—0.9	—3.6	140	4 45.2	—1.7	+1.1	221
14	9 Canc	6.2	0 13.6	—1.0	+1.9	69	1 21.8	—1.7	—0.4	299
18	ν Virg	4.2	3 24.3	—0.9	—1.0	146	4 31.6	—1.8	+1.0	271
OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′										
Feb. 8	64 Ceti	5.7	0 2.7	..	..	354	0 36.3	—3.2	—3.8	303
11	ι Taur	4.7	0 48.0	..	..	352	1 11.7	..	..	324
11	330 B.Taur	6.3	0 51.2	—2.2	—0.1	100	2 3.6	—1.7	+1.8	226
11	105 Taur	6.0	3 4.9	—1.8	+0.9	58	4 17.5	—1.4	—1.5	282
12	1 Gemi	4.3	0 4.2	—1.2	+1.6	69	1 19.8	—1.8	+0.7	266
18	ν Virg	4.2	3 16.0	—0.5	—2.1	166	3 58.2	—1.1	+3.1	243
OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′										
Feb. 11	330 B.Taur	6.3	0 2.8	—0.8	+1.6	70	1 12.7	—1.3	+1.6	248
11	105 Taur	6.0	2 9.0	—1.3	+2.3	46	3 22.6	—2.3	—0.2	277
11	n Taur	5.1	8 26.1	—0.9	—0.3	65	9 22.5	0.0	—1.6	290
12	9 Gemi	6.3	6 39.8	—2.2	+1.6	47	7 34.9	—0.9	—3.1	316

OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +30° 0′*

			h m	m	m	°	h m	m	m	°
Feb. 8	ξ^1 Ceti	4.5	0 39.6	—1.1	+2.6	21	1 43.7	—2.2	—1.1	275
11	ι Taur	4.7	0 3.3	—0.8	+2.8	34	1 9.9	—2.7	—0.3	284
11	105 Taur	6.0	2 46.8	—2.5	—0.2	91	4 10.4	—2.1	+0.5	245
11	1 Gemi	4.3	23 42.8	—1.2	+0.9	89	0 54.9	—1.4	+1.8	242
12	9 Gemi	6.3	7 17.2	—1.8	+1.1	45	7 58.9	+0.3	—3.1	326
13	9 Canc	6.2	23 39.2	—0.2	+1.1	82	0 41.9	—0.8	+0.8	276
17	BD+12°2284	6.4	4 1.0	—1.3	+1.4	83	5 7.4	—1.4	—1.8	326

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

In Memoriam.—It may seem strange that the first Notes of the new year should start with the mention of the loss of one of our members, Sterling Bunch of Texas, who died at Fort Worth last July 13. His example should be an inspiration to all amateurs. It had never been my privilege to know him personally, though for years he and I corresponded regularly on meteoric matters. These remarks are therefore, perforce, limited to what can be learned through such contacts. He joined in 1923 and, somewhat later, in cooperation with Oscar E. Monnig, he made Texas one of our most valuable states to the A.M.S. On moving to Tennessee he acted as regional director for several years, again making his adopted state one of our best, due to his personal work and enthusiasm. While there he was co-author with the writer (and deserved all the credit for collecting the data) on "Tennessee Fireball of August 21, 1933" published in the *Monthly Weather Review* and reissued as *F.O.R.* No. 23, and of "Daylight Fireball of 1934 December 2" in these Notes of August, 1943. He was, however, instrumental in gathering data on numerous other fireballs, and spent long hours in observing the principal meteor showers. Some of the results from these activities have been published, others still await reduction. In all ways he was a most valuable member and showed what an amateur can really accomplish. His loss is most deeply regretted as a blow to our Society and by the writer as that of a friend of long standing. A fine appreciation of him as a man appeared in *Texas Observers Bulletin*, No. 164.

Turning to the future, there is no reason why our work should not advance much more rapidly, now that the war is over and many of our members are returning to civilian life. Also we have had several scores of new members in the

past two years. A few of these have done excellently, some have worked on a few occasions, but the majority, so far as known, have taken no active interest whatever. With more normal conditions, these latter should begin observing and the former work with more regularity. The reprint covering the Meteor Notes for 1945 will soon be ready for distribution. It will be sent promptly to all members who have paid their 1946 dues by February 1. Incidentally, kindly do this without making us send bills, which takes time and postage, both of which can be used in better ways. We end the year with full supplies of maps, blanks, etc. And before 1946 is out we hope to have some new assistants at Flower Observatory, in which case more progress can be made in reducing data sent in by our members. However, if the 1945 Meteor Notes are read, it will be seen that a good deal was published during the past year, even though no assistance whatever in reducing or preparing the data was available.

Two interesting papers from Ole Rømer Observatory in Denmark, by Axel V. Nielson, Nr. 17 and 18 of their "Meddelelser" deal with meteors. The first has to do with the famous Pultusk meteor, the other is entitled "On Three Bright Meteors." The writer has nothing but commendation for Nielson's work, as presented, but wishes to quote from and then discuss some remarks on p. 237, dealing with radiants of fireballs. He says: ". . . it must be admitted that comparatively few radiants in our catalogues are reliable. It may be or it may not be that this judgment is a little too hard . . . it is often impossible to judge the reliability of a radiant as many papers . . . do not contain details necessary to support such a judgment. I fear that in such cases the theorists will prefer to exclude the radiant in question. . . I take the liberty of asking the computers of true paths . . . to publish so many details that each student may judge the reliability of the radiants."

Having dealt with over a hundred fireball paths, where we had anywhere from two to fully 400 reports on single cases, I can speak with some experience. When there are two to four reports only, it is quite possible to print them in all needed (abstracted) detail, and generally it has been done. But when the reports run into scores, this is utterly out of reason! Say one has 100 reports: probably 20 give information of use in computing some or perhaps all data for the path, 20 more will be useful for time estimates, physical features, etc., the other 60 can be, in part, used to check some of the conclusions. Every fireball must be solved as an individual case, a set procedure may be theoretically fine but practically, with such heterogeneous data, can hardly be followed. It is true, for example, that von Niessl, when apparently the Vienna Academy of Sciences had unlimited publication funds, used to take from 30 to 50 of their large pages to discuss a single fireball. But it is my frank opinion that, once he had published one fireball in full detail as a type example, most of the others could have been condensed to 3 to 5 pages each, with no loss to anyone. It was a shining example of useless detail, and I doubt if such articles would have been accepted in any but a German publication. Here there are no funds for such extravagance and, in any case, funds could be spent to far better advantage. However, I am further willing to admit that any other person, trained in meteor work, would, in cases where there are scores of observations and individual judgment *has* to be used, certainly derive paths in some cases somewhat different from what has been done by me or anyone else. But I do not think we are therefore justified in publishing page after page of abstracted reports, the reliability of which must be

judged by many things, some of which are obvious only when examining the original.

In another direction, in years past, some criticism has been leveled at the A.M.S. results because the writer was usually forced to collect his data through letters and questionnaires, and not by personal interviews. Here there is no argument but that personal interview is the ideal line of action, but the writer deals with the whole United States, to some extent, and rather specifically with certain states where we have active observers. Where possible, regional directors have been appointed. These men, in certain cases, are able to interview some of the observers. But so far as the writer personally is concerned, his professional duties wholly forbid traveling around seeking interviews, even in Pennsylvania. There are cases in which a single fireball would take all his time for a couple of weeks! Data *have* to be gathered through correspondence or not at all.

These thoughts lead to consideration of what has actually been published by the A.M.S. on fireballs. As they are scattered through many years of Meteor Notes, to say nothing of some other journals, it seems of interest to gather into one table the fireball paths computed here or published from here. Hence in the following table will be found: the date, the time (usually standard time of zone), right ascension and declination of the radiant, estimated accuracy of result, the sidereal time at end or ground point (sometimes one, sometimes the other, but they differ very little), the height at beginning, the height at end, the path length, the observed (that is uncorrected geocentric) velocity, notes, and A.M.S. Radiant number. Most of these last have not been assigned before. I request that they be entered at the proper places in past publications by all persons who use them, as they will serve for future reference. The letter c in the third column indicates that the radiant was corrected for zenith attraction, usually indeed assuming the heliocentric velocity was parabolic, and s that while this correction was not applied, yet it would have been small. In the the fourth column P indicates that I consider the result poor or uncertain; the rest may be considered good or fairly good unless the average deviations given for the heights are large. In a few cases two solutions had been published. I now choose that which seemed the more probable. The table is arranged by months rather than by years, as this makes it easier to compare with other lists particularly the von Niessl-Hoffmeister Catalogue. Incidentally, as we have scores of unsolved cases awaiting computation, some fully 15 years old, it has been largely a matter of chance as to which have been computed and published. Besides the 86 in the table, we have published data or partial solutions, but no radiants, for 36 others. These do not appear here.

Date			Time						H_1		H_2		L	V	
y	m	d	h	m	α	δ	Acc.	θ	km		km		km	km/ sec	No. AMS
32	1	02	10	:28	228°	+56°	c	139°.8	167		50		229		2229
45	1	07	8	:07	127	+68	c	45.0	146	± 27.2	40	± 17.5	159	55	2230
32	1	10	9	:28	160	+30	s	70	92	± 24	15	± 13	231	42	2231
39	1	11	14	:19	170	−19		141.2	159		56		139		2232
34	1	11	8	:02	323	+68.5	c	53	104	± 20	18	± 5	88	low	2233
41	1	21	10	:04	99	+16	s	90	183		15		184	19.4	2234
36	1	21	10	:25	315	+71	c	91	54	± 6	17	± 10	84	low	2235
31	1	22	6	:01	19	−54	c	31	112.4	± 32.3	89.4	± 18.4	527	42.5	2236
40	1	31	5	:55	4.0	−36.1	c ?	40.5	90.2	± 8.2	37.0	± 8.6	88		2237
38	2	07	6	:09	308	+53	c	45.7	147		42		229	114	2238
41	2	08	11	:58	135	+15.5		136.9	106.2	± 11.3	36.8	± 0.4	77	..	2239

Date y	m	d	Time h	m	α	δ	Acc.		θ	H_1 km	H_2 km	L km	V km/ sec	No. AMS
34	2	09	4	:50	114	+20			22.2	?	42	>202	slow	2240
39	2	24	13	:	193	+ 6		P	170	95.4 ± 15.9	9.4 ± 0.9	93	31	2241
41	2	26	7	:30	209	+48	c		85.1	136 ± 32	61 ± 18	359		2242
27	2	27	9	:00	43.2	+13.5	c		110	122.6 ± 29.6	30.3 ± 8.7	187	28.2	2243
35	2	27	6	:20	79.5	+45.7	c		69.2	(61.7 ± 7.8	31.1 ± 3.3	30.9)	*	2244
37	2	28	7	:40	119	+ 3.6	c		95.2	82.2 ± 8.6	47.6 ± 6.8	44.5	18	2245
42	3	07	7	:18	166	+ 1	c		95	104 ± 24	55 ± 17	158	41	2246
36	3	13	14	:47	161.1	+18.2	c		214.7	144	0.0	215	29—	2247
34	3	22	6	:26	145	+ 6		P	99	109 ± 44	19 ± 7	155	69	2248
33	3	23	18	:05	342.2	+ 9.4	c		258.0	141.2	16.6	656.5		2249
36	3	25	13	:	218	+23	c		218	175 ± 67	16 ± 10	0	35.3	2250
34	3	31	13	:24	157.3	−12.4	c		217	68.5 ± 13.8	20.8 ± 0.9	129	18.5	2251
44	4	04	7	:45	111	+43			111.3	71	<20	..	..	2252
34	4	04	11	:32	173	+10	s		184	96.7 ± 22.5	23.6 ± 0.4	99.4		2253
33	4	09	8	:22	202.3	+18.2			139.1	132	24	205	36	2254
38	4	12	7	:25	188	− 2			129	77.3 ± 24.5	16.9 ± 3.8	176	22+	2255
32	4	23	7	:35	131	−47		P	149	114	114	263		2256
31	4	29	14	:	9	+86	c		261	196.7	24.8	417	?	2257
30	5	03	8	:55	103.2	+43.8	c		171.5	141	37	146	32	2258
36	5	07	13	:32	3.6	+47.1	c		249.8	55	4	154		2259
22	5	11	11	:15	219.2	+ 4.4	c		214.9	209.5	6.4	243.9	59.1	2260
32	5	13	9	:32	92	+46.7	s		187.1	85.4 ± 1.4	38.3 ± 17.3	145		2261
36	5	17	7	:45	116	−35	c		166	90	52	248	?	2262
34	5	20	8	:44	204	− 9		P	119.3	179 ± 3	92 ± 1	133	32	2263
36	5	21	8	:	113.5	+45			..	..	..	..	..†	1956
22	5	28	10	:28	259	+ 7	c		218	126	38e	133+	33—	2264
22	5	30	8	:45	187	−37	c		194	103 ± 4	38 ± 16	165	20	2265
31	6	10	8	:11	250	−25	c	P	201	83	56	148	high	2266
37	6	14	14	:51	249	−41			299	84	47	254	39	2267
37	6	14	15	:44	227	−17			298	..	50	..	..	2268
27	6	21	13	:46	249.1	+11.8	c		297.1	71.0	18.5	50.7	17.6	2269
31	6	22	14	:	308	−31			299	128.2 ± 28.4	68.6 ± 27.2	104		2270
38	6	24	5	:40	145.5	+19.4	c		178	(19	16	6)	..*	2271
27	6	28	7	:48	240.0	−11.2	c		215.7	242	16	432		2272
29	7	10	9	:50	243	−28		P	247	59	15	171		2273
36	7	16	7	:50	128.1	+46.1	c		233.2	233	39	504	95	2274
13	7	21	8	:00	170	+ 1	c		235	103	30	166	52	2275
36	7	23	11	:48	22.6	+29.8	c		298	129	72.6 ± 1.5	117.3	39	2276
34	7	23	8	:30	290	−38.7	c		249	93 ± 9	54 ± 7	195	50	2277
33	7	23	12	:40	293.5	+51.2	s		311.2	169.3	36.8	147.2		2278
29	7	25	9	:14	271.7	+35.4			265.1	150.1	10.0	142		2223
29	7	25	9	:46	276.4	−20.2	c		271.4	221	11	377	51	2224
38	7	26	9	:02	216	−36	c		262.5	95	17	335	39	2279
29	7	27	10	:10	319	+14	c		273.4	104.8	4.6	144	22	2225
31	7	31	10	:30	178	+ 3			289	62.9	..	..	..	2280
24	8	01	13	:22	330	−56	c		330	203	147	263		2281
28	8	08	9	:28	287.6	+64.3	c		272.4	143.6	75.0			2282
41	8	11	9	:21	40.0	+59.4	c		273.2	207	101	347	(347)	2283
34	8	11	8	:25	52	+69		P	266	76	43	93	40‡	2284
44	8	17	19	:12	169.3	+17.6	c		75.4	166	31	546	31+	2285
33	8	21	7	:40	278.8	+64.7	c		271.0	170.8	45.6	144.0		2286
36	8	23	6	:21	110	+42	c		248	49	(59)	162	32	2287
34	8	30	9	:32	301	− 4	c		301.5	111	29	108	31	2288
34	8	31	7	:38	254	+33			281	148	27.3 ± 0.5	128	29	2289

Date y	m	d	Time h	m	α	δ	Acc.	θ	H_1 km	H_2 km	L km	V km/ sec	No. AMS
42	9	01	10	:30	1.5	−12.6	c	318	74.5 ± 12	20.8 ± 3.4	128	28	2290
33	9	03	6	:02	333	− 7	c	259	82	30	221	37	2291
41	9	08	8	:49	317	+30	s	299.5	59 ± 19	24	40+	slow	2292
33	9	15	8	:58	333	+ 9	c	312.6	86 + 1	16 ± 1	82	27	2293
32	9	21	17	:25	50	+42	s	81.2	80.8	6.3	83.0	28	2294
38	9	22	13	:48	211	+58	c	49	85 ± 6	62 ± 1	124	35	2295
28	10	07	9	:40	216	+82.6		335	160.9	1.6	406		2296
33	10	16	6	:50	309	+40	c	309	129 ± 15	12 ± 2	117	47	2297
34	10	17	9	:26	12	− 2	P	347	185 ± 66	52 ± 15	205	49	2298
36	10	21	8	:25	217	+64	c	338	145 ± 20	51 ± 6	199	50	2299
36	10	21	10	:29	109	+36.5	c	1.0	147	77 ± 5	324	54	2300
35	10	22	5	:12	247.2	+55.5	c	290.7	185.6 ± 44.1	35.4 ± 15.1	175	59+	2301
29	11	10	13	:	66.5	+18.0		66	72.6	36.7			2302
32	11	15	14	:08	157.5	+17.7	s	86.1	119.2 ± 4.5	85.8 ± 10.3	79.3§		2303
32	11	15	14	:35	149.6	+22.8	s	92.8	141.6 ± 12.0	72.8 ± 14.6	110.0§		2304
33	11	17	5	:07	56	+30	c	309.7	118 ± 25	50 ± 22	268	50	2305
34	12	02	4	:07	66	+24	c	316.2	60	40.2 ± 15.6	325	47	2306
41	12	10	8	:22	297	−17	c	25	76.6 ± 1.4	66.5 ± 9.7	236	19	2307
41	12	10	8	:22	336	−14	c	26	79.2 ± 3.8	56.4 ± 2.1	46		2308
43	12	18	12	:58	188	+36	c	101	187 ± 37	140 ± 4	115	23	2309

*Train only.
†Two fireballs.
‡Perseid.
§Leonid.

Flower Observatory, Upper Darby, Pennsylvania, 1945 December 18.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

Studies of the Meteoritic Falls of the World: 7. Numbers and Percents of Observed and Unobserved Falls of All Classes

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ABSTRACT

The substance of this paper is comprized within 2 tables entitled respectively, "1. Numbers and Percents of Observed and Unobserved Falls of All Classes," 1220 falls in all, recorded in Coulson's "Catalogue of Meteorites" (1940), and "2. Frequencies of Minimum and Maximum Percents of Observed Falls of the Principal Classes." The data of these tables are briefly reviewed, and several conclusions are stated. It is a noteworthy if not a remarkable fact that at least one representative of every known variety of aerolite has been observed to fall; this suggests, among other things, that aerolitic material may be present on the Earth which has not been recognized as such, simply because no sample of it has been seen to fall.

The essence of this paper is contained within Table 1, in which the first column (CL.) gives the symbol for the class of fall[1]; the second column (*O*), the number of observed falls; the third column (*U*), the number of unobserved falls; the fourth column ($T = O + U$), the total number of falls; and the fifth column (*O%*), the percent that the observed falls constitute, of each class. The symbols for the 3 main divisions of meteorites (**A**, **So**, and **Si**) are printed in boldface, while those for the 7 principal subdivisions thereunder (*Ac* and *C*; *Sa* and *Li*; *O*, *H*, and *D*) are set up in italics. The marks (*), (†), (‡), and (§), when affixed to a symbol, denote respectively the "total number of falls," "falls not further classified," "falls [in all cases chondrites, *C*] not further classified, except for veining and brecciation," and "falls further classified." The various classes are tabulated in precisely the same order as that in which they appear in Ch. 5, "Classified List of Meteorites, with Dates of Fall or Find," on pp. 232-79 of A. L. Coulson's "A Catalogue of Meteorites," *Memoirs of the Geological Survey of India*, **75**, 346 pp., 6 pl., 1940, with merely this difference, that those falls which Coulson enumerates on pp. 262-3 as "Siderolites," under "Stones," have been classified in the accompanying tables as "Sideraerolites" (*Sa*), under "Siderolites" (**So**), together with the "Lithosiderites" (*Li*), which he lists on pp. 264-6, under "Irons."[2] Nearly all of the data utilized in this study have been taken from Ch. 5 of Coulson's "Catalogue." While a total of 1258 falls is recorded in that "Catalogue," the following 38 have, in consideration of Study No. 6,[3] been excluded from the present investigation: all those of "Table 2. Doubtful Falls," except Minas Geraes, of which only the place seems to be in doubt (15 in all); and, of "Table 3. Duplicate and Possibly Duplicate Falls," these (rather arbitrarily rejected, in some cases, it must be confessed): Accalana, Altonah, Arabia, Barraba, Caparrosa, Carraweena, Cartoonkana, Corrizatillo, Durango, Huckitta Station,[4] Jefferson, Kandahar, Kanzaki, Kingoonya, Lampa, Mount Joy, Nativitas, Nejed, New Baltimore, Tiree, Warbreccan Run, Warialda,[4] and Windmill Station (23 in *toto*). For the falls of Table 4, *i.e.*, those of uncertain classification, the class here adopted has been in each case the primary class as reported, *i.e.*, either the class preceding the colon in the third column of that table or, in the cases of the following falls, the class parenthesized after the name of the fall: Barratta (*C*‡), Baxter (*C*‡),[5] Bridgewater (*O*†), Karoonda (*C*‡), Lyubimovka (*Ac*†), Tanezrouft (*C*‡), and Tysnes Island (*C*‡). For the falls of Table 5, *i.e.*, those having intermediate or plural classes, the class here assumed has been the first one named in the third column of that table, except in the following cases, for which the accepted class appears in parentheses after the name of the fall: Ojuelos Altos (*C*‡), Persimmon Creek (Off), and Quartz Mountain (Og).

Falls concerning the observation of which any doubt is expressed in Coulson have, without exception, been treated as unobserved falls in this study. The only sideritic and siderolitic falls of which the observation is considered authentic are the 37 falls (27 sideritic and 10 siderolitic) of Table 1 of Study No. 5.[6] Altho the 18 falls of Table 2 of that study likewise are recorded in Coulson, some as observed and others as possibly observed, they are all here regarded as unwitnessed.

On account of the foregoing facts, some differences will be detected between the data in the fourth column of Table 1 of the present study and those in the second column of "Table 2. The Classificational Distribution of the Meteoritic Falls of the World," of Study No. 4.[7] Wherever discordances exist, the data of

this later and more critical study naturally supersede those of the earlier one.

TABLE 1. NUMBERS AND PERCENTS OF OBSERVED AND UNOBSERVED FALLS OF ALL CLASSES

Cl.	*O*	*U*	*T*	*O*%	Cl.	*O*	*U*	*T*	*O*%
M*	587	633	1220	48.1	Cca	11	4	15	73.3
M†	2	7	9	22.2	Ccb	14	1	15	93.3
M§	585	626	1211	48.3	Cco	3	1	4	75.0
A*	548	165	713	76.9	Ccn	1	0	1	100.0
A†	51	55	106	48.1	Cck*	14	4	18	77.8
A§	497	110	607	81.9	Cck†	13	4	17	76.5
*Ac**	48	7	55	87.3	Cck§ = Ccka	1	0	1	100.0
Ac†	1	2	3	33.3	Ck*	20	20	40	50.0
Ac§	47	5	52	90.4	Ck†	14	15	29	48.3
Bu	2	0	2	100.0	Ck§	6	5	11	54.5
Chl*	6	0	6	100.0	Cka	3	3	6	50.0
Chl†	5	0	5	100.0	Ckb	3	2	5	60.0
Chl§ = Chla	1	0	1	100.0	Cek	5	1	6	83.3
Wht [or Cu]	1	0	1	100.0	**So***	10	46	56	17.9
An	2	0	2	100.0	**So†**	0	0	0	—
Cha	1	0	1	100.0	**So§**	10	46	56	17.9
Am	3	0	3	100.0	*Sa**	7	11	18	38.9
Ro	4	0	4	100.0	*Sa†*	0	3	3	0.0
Eu	11	3	14	78.6	*Sa§*	7	8	15	46.7
She	2	0	2	100.0	Ms*	6	8	14	42.9
Ho*	13	1	14	92.9	Ms†	3	3	6	50.0
Ho†	12	1	13	92.3	Ms§ = Msg	3	5	8	37.5
Ho§ = Hob	1	0	1	100.0	Lo	1	0	1	100.0
Ur	2	1	3	66.7	*Li**	3	35	38	7.9
C*	449	103	552	81.3	*Li†*	1	0	1	100.0
C‡	28	16	44	63.6	*Li§*	2	35	37	5.4
C§	421	87	508	82.9	Sy	0	1	1	0.0
Cho*	9	0	9	100.0	P*	2	34	36	5.6
Cho†	8	0	8	100.0	P†	1	14	15	6.7
Cho§ = Choa	1	0	1	100.0	P§	1	20	21	4.8
Cw*	96	9	105	91.4	PK	0	7	7	0.0
Cw†	52	5	57	91.2	PR	0	9	9	0.0
Cw§	44	4	48	91.7	PI	1	3	4	25.0
Cwa	38	3	41	92.7	PB	0	1	1	0.0
Cwb	6	1	7	85.7	**Si***	27	415	442	6.1
Ci*	62	6	68	91.2	**Si†**	1	44	45	2.2
Ci†	28	2	30	93.3	**Si§**	26	371	397	6.5
Ci§	34	4	38	89.5	*O**	20	297	317	6.3
Cia	26	4	30	86.7	*O†*	3	6	9	33.3
Cib	8	0	8	100.0	*O§*	17	291	308	5.5
Cg*	99	23	122	81.1	Off	0	16	16	0.0
Cg†	41	11	52	78.8	Of*	4	48	52	7.7
Cg§	58	12	70	82.9	Of§ = OfV	1	0	1	100.0
Cga	31	2	33	93.9	Of†	3	48	51	5.9
Cgb	27	10	37	73.0	Om	9	138	147	6.1
Co	1	0	1	100.0	Og	2	62	64	3.1
Ct	1	0	1	100.0	Ogg	0	16	16	0.0
Cs*	10	7	17	58.8	Ob*	2	8	10	20.0
Cs†	9	6	15	60.0	Ob†	1	1	2	50.0
Cs§ = Csa	1	1	2	50.0	Ob§	1	7	8	12.5
K*	15	0	15	100.0	ObK	0	1	1	0.0
K†	12	0	12	100.0	ObN	0	1	1	0.0
K§ = Kc*	3	0	3	100.0	ObZ	0	2	2	0.0
Kc†	2	0	2	100.0	ObZG	1	0	1	100.0
Kc§ = Kca	1	0	1	100.0	ObC	0	3	3	0.0
Cc*	103	21	124	83.1	OH	0	3	3	0.0
Cc†	60	11	71	84.6	*H**	4	26	30	13.3
Cc§	43	10	53	81.1	*H†*	0	0	0	—

TABLE 1 (CONT.)

CL.	*O*	*U*	*T*	*O*%	CL.	*O*	*U*	*T*	*O*%
H§	4	26	30	13.3	D_1Sh	0	1	1	0.0
Hn	4	19	23	17.4	D_1B	0	8	8	0.0
Ha	0	1	1	0.0	D_1L	0	3	3	0.0
Hb	0	6	6	0.0	D_2*	1	24	25	4.0
*D**	2	48	50	4.0	D_2†	0	8	8	0.0
D†	1	2	3	33.3	D_2§	1	16	17	5.9
D§	1	46	47	2.1	D_2N	1	3	4	25.0
D_1*	0	22	22	0.0	D_2S	0	9	9	0.0
D_1†	0	5	5	0.0	D_2P	0	3	3	0.0
D_1§	0	17	17	0.0	D_2T	0	1	1	0.0
D_1C	0	5	5	0.0					

TABLE 2. FREQUENCIES OF MINIMUM AND MAXIMUM PERCENTS OF OBSERVED FALLS OF THE PRINCIPAL CLASSES

CL.	MIN. *O*%	*O*%*	MAX. *O*%
M: 86	0%: 23: 27%	48%	100%: 24: 28%
A: 45	33%: 1: 2%	77%	100%: 20: 44%
Ac: 14	33%: 1: 7%	87%	100%: 10: 71%
C: 30	48%: 1: 3%	81%	100%: 10: 33%
So: 11	0%: 5: 45%	18%	100%: 2: 18%
Sa: 4	0%: 1: 25%	39%	100%: 1: 25%
Li: 7	0%: 4: 57%	8%	100%: 1: 14%
Si: 29	0%: 18: 62%	6%	100%: 2: 7%
O: 14	0%: 7: 50%	6%	100%: 2: 14%
H: 3	0%: 2: 67%	13%	17%: 1: 33%
D: 11	0%: 9: 82%	4%	33%: 1: 9%

"Table 2. Frequencies of Minimum and Maximum Percents of Observed Falls of the Principal Classes" gives information for all of the 1220 falls of Table 1 combined, and for the 1211 of them that are further classifiable under one or 2 of the 10 principal categories of meteorites. In the first column of Table 2 are listed: first, the symbol for the category and, second, the number of classes thereunder, *i.e.*, all the classes enumerated in Table 1, except those marked by an asterisk (*) or by a "section" (§); in the second column: first, the numerical value of the minimum percent for the category; second, the number of classes having that value; and, third, the percentage ratio of that number to the total number of classes (*cf.* column one); in the third column (headed "*O*%*"): the percent that the observed falls constitute of the class with the starred symbol in Table 1, reproduced from that table for convenience of reference; and, in the fourth column: exactly the same kind of information for the maximum percent as is exhibited, in the second column, for the minimum percent.

Inspection of the tables shows that, with the exception of a single class (*i.e.*, *Ac*†, for which *O*%* = 33), the percents for the observed aerolitic falls range upwards from 48, in the large majority of cases exceed 70, and average 77, while in no fewer than 20 cases these percents are equal to 100. On the other hand, with but 2 exceptions (namely the classes OfV and ObZG, of which there is only one recorded fall each and that witnessed), the percents for the observed siderolitic falls never exceed 50, in most cases are less than 10, and average 6, whereas in as many as 18 cases these percents are equal to 0. As would naturally be expected, in view of the intermediary character of the siderolitic falls, the percents for the observed falls range all the way from 0 to 100, with an average of 18, while, for the sideraerolites (which are most like aerolites), the minimum, maximum, and average percents for the observed falls are respectively, 0, 100, and 39,

and for the lithosiderites (which are most like siderites), the percents are 0, 100, and 8.[2]

Since the data of Tables 1 and 2 are largely self-explanatory, no extended discussion of them is required. It is, however, a noteworthy if not remarkable fact that at least one representative of every known variety of aerolite has been observed to fall. This suggests the possibility that there is present on the Earth no inconsiderable quantity of aerolitic material that has never been identified as being of cosmic origin, either because no such material has been seen to fall or because it has been altered to such an extent that it is no longer recognizable as having been meteoritic,[8] and that aerolites, especially those that are most liable to terrestrial disintegration and those that belong to the several classes of which all the falls thus far reported have been witnessed, are much more abundant than they are commonly supposed to be;[9] and it has a bearing on the apothegm that, unless an aerolite is recovered soon after its fall, it is likely to weather away and to become, even to the meteoriticist, practically indistinguishable from an earthly stone.

NOTES AND REFERENCES

[1] "Table 1. Alphabetical List of Classificational Symbols for Meteorites," in Study No. 6, "Doubtful and Duplicate Falls and Falls Having Uncertain and Intermediate Classifications," *C.S.R.M., P. A.*, **53**, 464-72, 1945, will serve as the key to the symbols used.

[2] *Cf.* F. C. Leonard, "On the Classification of Meteorites," *C.S.R.M.*, **3**, 134-6; *P. A.*, **52**, 148-51, 1944.

[3] Ref. in n. (1), *ante*.

[4] Huckitta Station and Warialda appear also in Table 4 of Study No. 6.

[5] *Cf.* H. H. Nininger on "The Meteorite which Penetrated a Roof at Baxter, Missouri," *C.S.R.M.*, **2**, 53-5; *P. A.*, **46**, 407-9, 1938.

[6] "The Observed Sideritic and Siderolitic Falls," *C.S.R.M.*, **3**, 73-8; *P. A.*, **51**, 161-7, 1943. There are 38 falls in Table 1 of Study No. 5, including the famous Podkamennaya Tunguska River fall of central Siberia of 1908 June 30. While that fall is probably sideritic, it is regarded by Coulson (*cf.* pp. 216 and 233 of his "Catalogue") as being of unknown classification, and it is so treated in the present study, in which it is one of the 2 falls tabulated under the heading of "Mi†: *O*" (Table 1, *ante*).

[7] *C.S.R.M.*, **3**, 65-70; *P. A.*, **51**, 44-9, 1943.

[8] Much of the so-called "meteoritic shale," which is oxidized sideritic, rather than aerolitic, material, found at the Canyon Diablo, Arizona, Meteorite Crater, and elsewhere, is approaching this condition.

[9] H. H. Nininger has, I believe, reached the same conclusion, as a result of his extensive field explorations.

"Second Appendix to the Catalogue of Meteorites" of the British Museum, By Max H. Hey (Review)

The "Catalogue of Meteorites with Special Reference to those Represented in the Collection of the British Museum (Natural History)," x + 196 pp., 1923, and its first "Appendix," 48 pp., 1927, by the late G. T. Prior, M.A., D.Sc., F.R.S., Keeper of the Mineral Department of the Museum, published by the Museum, are indispensable works in the library of every meteoriticist. Altho a "Second Appendix," 136 pp. (price, 5 shillings), by Max H. Hey, M.A., D.Sc., Assistant Keeper in the Department of Mineralogy of the Museum, designed "to include all meteorites described since the publication of the first appendix, up to the end of September, 1939," made its appearance as long ago as 1940, a copy—presumably on account of war-time conditions—has just reached us. This "Second

Appendix," together with its predecessors, constitutes a veritable *vade mecum* for all serious students of meteorites.

In the "Preface," pp. 5-7, are included a list of 51 falls "classed as doubtful," and a list of 47 "paired" falls, "which it has been suggested are possibly or probably identical." The original "catalogue and appendices now contain entries for 1251 reasonably well-authenticated falls (of which 758 are represented in the Museum collections), and for a further 98 'doubtful' and 'paired' falls (24 in the collections)." On pp. 9-126 is the catalogue of falls which are included in this "Second Appendix" and which are described in the same generally satisfactory fashion as are those incorporated in Prior's original "Catalogue" and its first "Appendix." A novel, interesting, and valuable feature of the current "Appendix" is the detailed inventory, on pp. 127-32, of "11 reasonably authenticated [meteorite] craters" and 9 "doubtful or discredited craters," or groups of craters. Finally, on p. 133, is a "List of the Casts of Meteorites in the British Museum Collection," and, on pp. 134-6, an enumeration of the "Thin Sections of Meteorites and Pseudo-meteorites" in the collection. Dr. Hey is to be congratulated on the publication of this important contribution to the records of meteoritics.

FREDERICK C. LEONARD

1945 November 12

Note on the Fairplay, Missouri, Iron

I have just read the very valuable tables of meteoritic falls in *C.S.R.M., P. A.*, **53**, 464-72, 1945,* and I note that, in Table 2, the Fairplay, Missouri, iron is listed among the "Doubtful Falls." There is no doubt at all about Fairplay, it being white cast iron. I examined it metallographically several years ago, and the structure of pearlite and ferrite was characteristic. I so advised Dr. H. H. Nininger at the time; in fact, I examined it at his request, but he probably had already reported it as a doubtful meteorite, and thus it was included in Coulson's "Catalogue."

I hope that in time all meteoritic irons can be studied metallographically, for, until they are, the classifications of many of them will be more or less doubtful.

STUART H. PERRY

Adrian, Michigan, 1945 November 24

*Frederick C. Leonard, "Studies of the Meteoritic Falls of the World: 6. Doubtful and Duplicate Falls and Falls Having Uncertain and Intermediate Classifications."

President of the Society: LINCOLN LA PAZ, Department of Mathematics and Institute of Meteoritics, University of New Mexico, Albuquerque

Secretary of the Society: C. H. CLEMINSHAW, Griffith Observatory, P. O. Box 9866, Los Feliz Station, Los Angeles 27, California

Comet Notes

By G. VAN BIESBROECK

Comet Friend-Peltier

An unexpected comet was discovered in the evening sky by Mr. Clarence L. Friend at his private observatory at Escondido (Cal.) on November 22. This is the third new comet found by this active observer, who has to his credit comets 1939*n* and 1941*a*. The first announcement gave the following information through the central bureau of astronomical telegrams at the Harvard College Observatory:

1945 November 22 Right ascension $16^h 20^m$ Declination $+30°$ Magnitude 7.

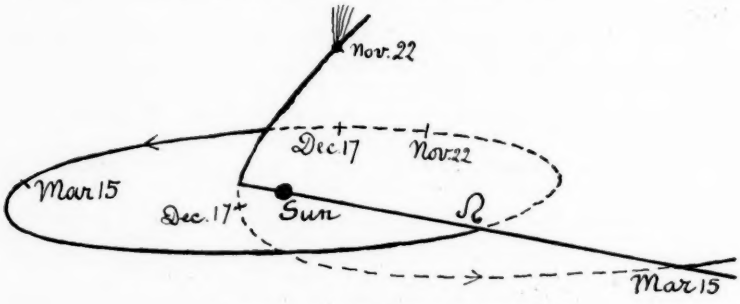
Two days later the comet was independently found by L. Peltier, the veteran comet-hunter of Delphos (Ohio) whose discoveries are so numerous that they are hard to keep track of. He gave the rough position:

1945 November 24 Right ascension $16^h 25^m$ Declination $+26°$ and the magnitude 8.

The comet was almost in conjunction with the sun at this time and could be seen only for a short time after sunset. Soon, however, its exact location was determined at various observatories especially by H. L. Giclas at Flagstaff (Ariz.) who by November 29 gave the magnitude as 6 and adds that the diffuse comet showed a nucleus and a short tail.

From these data L. E. Cunningham at Aberdeen (Maryland) computed the following preliminary orbit:

Perihelion date 1945 December 17.282 U. T.		
Node to perihelion	216° 43′	1945.0
Longitude of node	325° 24′	
Inclination	49° 29′	
Perihelion distance 0.1945 astr. units.		



Orbit of Comet Friend-Peltier

The figure shows the position of the earth and the comet relative to the sun. While the earth describes its nearly circular orbit around the sun and occupies the positions indicated on November 22, December 17, and 1946 March 15, the comet describes its long parabolic orbit from its position on November 22 at discovery to its minimum distance from the sun on December 17 and passes from below to above the earth's orbit on March 15, when the ascending node line is reached. The drawing shows how the comet is moving rapidly southward in

December and remains at a small angular distance from the sun which limits observations to twilight. Maximum brightness was due in the middle of December when the comet was a morning object. After that date it is hidden behind the sun. The following positions are deduced from Cunningham's elements:

		α	δ
		h m	° ′
1945	Dec. 31	19 8.1	−32 31
1946	Jan. 4	19 34.6	−30 58
	Jan. 8	19 56.5	−29 17
	Jan. 12	20 15.1	−27 35
	Jan. 16	20 31	−26 00
	Jan. 20	20 45	−24 24
	Jan. 24	20 57	−22 42
1946	Jan. 28	21 08	−21 30

This indicates that the comet will remain lost in the sun's glare for quite a while and when it gradually emerges in the morning sky its distances from the sun and the earth will have increased so much that the brightness will have gone down enormously. The conditions of visibility are therefore most unfavorable for observers in both hemispheres.

The other comets under observation are quite faint. Periodic Comet Kopff had dropped to magnitude 14 on November 30 as recorded on a plate taken by the writer with the 82-inch reflector of the McDonald Observatory. It appeared as a fuzzy coma some 2′ in diameter with a nearly starlike nucleus and a broad tail in the direction opposite from the sun. The comet will soon be lost in the evening sky.

Periodic Comet Väisälä (1944 *b*) remains around magnitude 16 (December 4) and is reduced to a round coma of some 10″ in diameter. It is well condensed centrally and would be difficult to distinguish from a star on a small scale image.

Periodic Comet Schwassmann-Wachmann has not continued to brighten up as was expected last month. In the period November 30 to December 7 it remained as faint as magnitude 18 but changed its appearance from a practically stellar image to a fuzzy nucleus with only the faintest trace of nebulosity. It will be well, however, to watch this object for further outburst of light.

McDonald Observatory, Fort Davis, Texas, December 14, 1945.

General Notes

Dr. Edwin P. Hubble, who was absent from Mt. Wilson while engaged on research on war projects, has returned to his extragalactic research at the Mt. Wilson Observatory, Pasadena, California.

Ira S. Bowen, professor of physics at the California Institute of Technology, has been appointed director of the Mount Wilson Observatory to succeed Walter S. Adams who retires on January 1, 1946, after serving twenty-three years as director. (*P. A. S. P.* December, 1945.)

Dr. George W. Ritchey, well known for his work in designing and constructing lenses and mirrors for telescopes both in this country and in Europe, died at his home in Azusa, California, on November 4, 1945.

Dr. Charles D. Shane, of the department of astronomy of the University of California, assumed his new duties as director of the Lick Observatory on December 1, 1945. Dr. Shane succeeds Dr. J. H. Moore, who will continue as a member of the Observatory staff residing in Berkeley.

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on December 14. Dr. K. Aa. Strand, of Swarthmore College, addressed the meeting on the subject "Recent Advances in Aerial Navigation."

Neighborhood Astronomers,—Astronomers in Cleveland, Ohio, and vicinity have arranged a series of four meetings for the current season. One was held on November 10, at which Dr. Leo Goldberg, of the McMath-Hulbert Observatory of the University of Michigan, spoke on the subject, "Recent Progress in Solar Physics." The meeting held at the Warner & Swasey Observatory, Cleveland, Ohio. Other meetings will be held as follows: Saturday, March 9, 1946, at 2:00 P.M., Dr. Charlotte M. Sitterly of Princeton University will speak on "Problems Related to Infra Red Color Spectroscopy" at the Warner & Swasey Observatory, Cleveland, Ohio. Saturday, April 6, 1946, 2:00 P.M., Dr. S. Chandrasekhar of the Yerkes Observatory, University of Chicago, will speak on "The Continuous Absorption Coefficient in Stellar Atmospheres" at the Warner & Swasey Observatory, Cleveland, Ohio. June 1946, Meeting will be in Columbus, Ohio. Notice of speaker and subject not yet decided on.

The Cleveland Astronomical Society

The December 7 meeting of the Society consisted of a Christmas party. On the more serious side, the film "Exploring the Universe" was shown, also astronomical slides including kodachrome slides of stellar spectra and the Orion nebula in natural colors taken with the Schmidt-type telescope at the Warner and Swasey Observatory.

On the less serious side, the master of ceremonies, Hal Metzger, of radio station WTAM, helped the party get acquainted by using his novel altazimuth method of introduction. Each person introduced himself to the person on his left, his right, below and above him, as they were seated in the auditorium. Christmas carols, Santa Claus, and refreshments completed the evening.

HENRY F. DONNER.

Western Reserve University, Cleveland 6, Ohio.

The Observer, the official publication of the Yakima (Washington) Amateur Astronomers, has changed its form to a printed four-page. The first issue in this form is No. 1 of Volume 7. This publication has now been resumed after a suspension during the war period. The plan is that one number of this series is to be issued each month. The editor of it, Mr. Edward J. Newman, a member of the 13th Airborne Division in France was discharged from the army on October 7.

Dutch Astronomers—War Victims

Word has recently reached us through Dr. Peter van de Kamp that the following named Dutch astronomers in the Netherlands East Indies have died as a result of exhaustion while prisoners in the hands of the Japanese. Dr. Arnaut de Sitter, Acting Director of the Bosscha Observatory; Dr. W. Chr. Martin, Bosscha Observatory; Mr. J. Uitterdyk, teacher in Batavia.

Book Review

Vapor Adsorption, by Edward Ledoux. (Chemical Publishing Co., Inc., Brooklyn, N. Y., 1945. Price $8.50.)

Interest in the unit operation of adsorption has increased greatly during the last decade. Extensive studies have been made on the adsorption of gases, liquids, and solids on solid surfaces. The use of this tool has gradually emerged from an empirical application to processes for which definite laws have been established and for which equipment can be designed based on rigorous mathematical calculations.

The exact nature of the physical and chemical processes taking place during the adsorption of one material by another are not fully understood, and it is impossible to predict accurately the efficiency of an adsorbent for any given material. Extensive progress has been made recently, however, in the correlation of adsorption data which allow the theoretical investigator and the chemical engineer to study these processes with a minimum of experimental data, thereby increasing the rate at which progress in this field of science is made.

Dr. Ledoux gives an up-to-date summary of the principles underlying the study of adsorption and the design of adsorption equipment. The book is divided into two broad parts. The first part deals with the problem of static adsorption and discusses the laws and theories as well as the latest methods of correlation of equilibrium adsorption and heats of adsorption. It also gives the reader a clear picture of the effect of external forces on the equilibrium and thermodynamics of the adsorption system.

The second part is devoted to the study of dynamic adsorption of vapors and gases and deals more with problems of a practical nature such as are encountered by the chemical engineer in the use of this operation.

The book is well written and illustrated with numerous diagrams and flow sheets. It deals exclusively with the problem of vapor adsorption both from a theoretical and an engineering viewpoint. It should therefore be of immeasurable help both to the operating engineer who is using vapor adsorption processes, and to the design and process engineer who contemplates the use of adsorption for the purification, removal, or treating of vapors in his process.

The book furthermore stresses the importance of the heats involved in the adsorption process and describes in detail numerous applications of this unit operation in industry.

Dr. Ledoux has filled a need of the chemical engineer by supplying him with a book which is both a textbook and a reference book on vapor adsorption. It is heartily recommended to anyone who is interested in the growing use of the unit chemical engineering operation of vapor adsorption.

SAMUEL JOSEFOWITZ and DONALD F. OTHMER.

Polytechnic Institute of Brooklyn, December 7, 1945.

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